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CYTOGENETIC AND GENETIC ANALYSES
OF CERTAIN CHARACTERS IN COMMON WHEAT
USING WHOLE CHROMOSOME SUBSTITUTION LINES

J. Kuspira
April, 1955

Department of Plant Science
University of Alberta

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CYTOGENETIC AND GENETIC ANALYSES
OF CERTAIN CHARACTERS IN COMMON WHEAT
USING WHOLE CHROMOSOME SUBSTITUTION LINES

A DISSERTATION
SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF DOCTOR OF PHILOSOPHY


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DEPARTMENT OF PLANT SCIENCE

by

John Kuspira

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1. Introduction

The purpose of this study is to investigate the effects of the proposed system on the performance of the system.

The study is organized as follows: Section 2 describes the system architecture. Section 3 describes the experimental setup. Section 4 presents the results of the experiments. Section 5 discusses the conclusions.

2. System Architecture

The system architecture is shown in Figure 1. The system consists of a client and a server.

The client is responsible for the following tasks:

- To send requests to the server.

- To receive responses from the server.

The server is responsible for the following tasks:

- To process requests from the client.

- To store data.

- To return data to the client.

The system is implemented using the following technologies:

3. Experimental Setup

The experiments were conducted on a system with the following specifications:

- Processor: Intel Core i7-4790K

- Memory: 16 GB

- Storage: 1 TB

The experiments were conducted using the following tools:

4. Results

The results of the experiments are shown in Table 1.

The results show that the proposed system

significantly improves the performance of the system.

The results also show that the proposed system

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THE HISTORY OF THE

CHAPTER I

1. The first part of the history, from the beginning of the world to the birth of Christ, is divided into three ages, the antient, the middle, and the modern.
2. The second part of the history, from the birth of Christ to the present time, is divided into three ages, the antient, the middle, and the modern.
3. The third part of the history, from the present time to the end of the world, is divided into three ages, the antient, the middle, and the modern.
4. The fourth part of the history, from the end of the world to the present time, is divided into three ages, the antient, the middle, and the modern.
5. The fifth part of the history, from the present time to the end of the world, is divided into three ages, the antient, the middle, and the modern.

CYTOGENETIC AND GENETIC ANALYSES OF CERTAIN
CHARACTERS IN COMMON WHEAT USING WHOLE
CHROMOSOME SUBSTITUTION LINES.

I INTRODUCTION

Genetic analyses of quantitative characters in polyploid organisms such as the hexaploid common wheat, Triticum vulgare Vill., (= Triticum aestivum L. emend Fiori et Paoletti), have only rarely been successful. The chief reason for failure is that polyploids are not very amenable to orthodox methods of genetic analyses. This is due to several factors:

- (a) the duplication or even triplication of genic material,
- (b) the presence of minor genes or modifiers,
- (c) the difficulty or impossibility of making accurate classifications of segregants,
- (d) the difficulty of determining linkages because of the large number of chromosomes.

With the isolation of plants with various chromosomal aberrations in common wheat by Sears a new method of analysis has been made possible. Using *nullisomics, **monotelosomics or ***mono-isosomics for the twenty-one chromosomes in Chinese Spring+, single chromosomes of this variety can be replaced by their homologues from the donor variety. The effect of genes on these substituted chromosomes on various quantitative and qualitative characters can be studied in a uniform genetic background of Chinese by comparing substitution lines with the normal recipient variety.

This report deals with the use of three distinct sets of Chinese substitution lines in studying the genetics of awning, earliness, height, lodging, protein content, spike density, thousand-kernel weight and yield. The first set of Chinese substitution lines comprises 19 chromosomes of Thatcher substituted for their respective homologues in Chinese; chromosome XIV and XVII lines are not included in this study. The remaining two sets are composed of Hope and Timstein chromosomes respectively. Chromosome lines XIII and XIV in both of the latter sets were not available when the study was begun.

*Nullisomic - any individual deficient for a single pair of homologous chromosomes ($2n-2$).

**Monotelosomic - an individual which has twenty pairs of chromosomes and a telocentric chromosome for one of the arms of either chromosome of the missing pair.

$20'' + \text{telocentric}$

***Mono-isosomic - an individual which has twenty pairs of chromosomes and an isochromosome for one of the arms of either chromosome of the missing pair.

$20'' + \text{isochromosome}$

+ Throughout the report Chinese Spring is contracted to Chinese.

The present report is the result of a study of the
available data in regard to the number of cases, patients, and
deaths, between 1900 and 1910, in the United States, and
the results of the study are given in the following
pages of the report. The data are given in the form of
tables, and the results are given in the form of
statements. The data are given in the form of
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deaths, between 1900 and 1910, in the United States.

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deaths, between 1900 and 1910, in the United States.

II REVIEW OF LITERATURE

1. Cytologic Investigations of Nullisomics, Monosomics, Telocentric Chromosomes, and Isochromosomes.

A. Cytologic Investigations of Monosomic Plants

Monosomics are diploid or polyploid individuals that are deficient for an entire chromosome. The best known monosomic in diploids is the haple - IV type of Drosophila melanogaster. Apparently, because of duplication of essential genetic material, polyploids can tolerate deficiencies that would result in the death or partial development followed by death in diploid organisms who have smaller reserves of essential genetic material. Thus monosomic individuals are obtained much more frequently and readily in polyploids than in diploids.

Clausen (18) reported obtaining 20 of the 24 possible monosomics in Nicotiana tabacum ($2n=48$) and Clausen and Cameron (19) reported that the 24 different monosomics had been isolated. These different monosomics have been used with marked success in associating genes with chromosomes. In associating recessive genes with particular chromosomes a normal recessive line is crossed with each of the 24 monosomics. The resulting F_1 populations for the respective chromosomes are composed of both monosomic and disomic plants. In the critical F_1 family only the monosomic plants are of the recessive phenotype and all the disomic plants exhibit the dominant form of the characteristic as do all plants in non critical families. To test for the association of dominant genes with chromosomes, the dominant type is crossed to each of the 24 monosomic lines. The F_1 's are selfed and F_2 populations are grown. The critical F_2 family shows no recessive segregates since nullisomics are not obtained because the 23-chromosome pollen is not viable. In non-critical F_2 families the expected number of recessive segregates

will appear. Duplicate genes for chlorophyll production in Nicotiana Tabacum have been located by Clausen and Cameron (20) using monosomic analysis.

Olmo (57) described 7 monosomic types of Nicotiana Tabacum var. purpurea which originated from progenies of interspecific hybrids or through non-conjunction of chromosomes in otherwise normal plants. He observed that monosomics were less fertile than the normal purpurea strain and he calculated that 45.6 to 83.2% of the female gametes of monosomic plants were $n-1$ while the transmission of $n-1$ male gametes of monosomic plants ranged from 0 to 7% with 2% being an approximate average.

Lammerts (44) working with Nicotiana rustica ($2n = 48$) studied the transmission of whole chromosome deficiencies through the eggs and pollen. The percentage of functional female $n-1$ gametes of monosomic plants ranged from 31 to 75%. This range in percentage of functional female $n-1$ gametes was due mostly to differential lagging of the univalent. In certain cases low transmission of the deficiency may be due to: (a) selective development at 4-celled stage of megasporogenesis, (b) frequent failure of $2n-1$ zygotes to complete normal seed development.

In only 3 of the 7 monosomics studied was the deficiency transmitted with an appreciable frequency through the pollen. Lammerts stated that, "viability of $n-1$ gametes and $2n-2$ zygotes is evidence that a species is polyploid".

Greenleaf (31) studied transmission of n and $n-1$ female gametes in monosomic types of Nicotiana Tabacum. On the basis of cytological observations he concluded that two causes were responsible for lowered transmission of $n-1$ functional eggs: (a) slow rate of development of $n-1$ embryo sacs and (b) a higher frequency of embryo sac abortion prior

to the 8-nucleate stage. He assumed that the frequency of univalent elimination is the same in megasporogenesis as in microsporogenesis and that about 80% of all megaspores are n-1, regardless of the chromosome concerned. Frequency of functioning of n-1 embryo sacs would then depend on the relative importance of the missing chromosome in the process of embryo sac development.

Many investigations of whole chromosome deficiencies have been carried on in common wheat (T. vulgare). In most of these cases, the deficiency concerned was chromosome IX(C) which when present as a monosome causes heterozygous speltoidy as shown by Huskins (36, 37), Huskins and Spier (38), Hakansson (cited by Sears, 71) and Sears (71). Two monosomics were found by Nishiyama (56) among the progeny of a cross between two nullisomics of F_4 (T. polonicum x T. spelta) x T. spelta. Powers (62) found that two of the 32 Marquillo plants he examined were monosomic. Love (48) obtained numerous monosomic plants in 50 lines derived from crosses of 4 varieties of T. vulgare with T. durum var. Tumillo. Sears (69, 71, 76) has isolated all 21 possible monosomic types in the common wheat variety Chinese.

Nishiyama (56) who studied transmission of effective n and n-1 gametes through both the male and female in monosomics of the forementioned cross found the proportion of 20-and 21-chromosome megaspores in the ratio of 73:27, and that the ratio of 20-and 21-chromosome microspores was 11:89. Powers (62) found that $23.4 \pm 0.24\%$ of microspores of monosomic plants showed micronuclei. On the basis of the number of microspores showing micronuclei the expected ratio of 20:21 chromosome female gametes was determined as 74:26. Sears (69) outlined the possible methods of origin of monosomics and in a later paper (71) reported that in monosomics 75% of the functional female gametes are

deficient for the monosome regardless of the chromosome concerned. Male transmission of functional 20-chromosome gametes varies from approximately 1 to 15% depending on the chromosome. No evidence was found of any selection against $n-1$ gametes such as that observed by Greenleaf (31) in Nicotiana Tabacum. Regarding transmission of deficiencies by both male and female gametes, the results of these three workers are in close agreement.

In the studies of Powers (62) and Myers and Powers (52), the presence of micronuclei in quartets was found to be correlated with the monosomic condition. The percentage of microspores showing micronuclei in disomics of Marquillo, Marquis, Minnesota 2303, and in monosomic plants of Marquillo was 23.4 ± 0.24 , 2.8, 0.8, and 0.8% respectively. Observations showed that genetic irregularities and meiotic instability were often associated with cytologic anomalies. Love (48) reported that the percentage of quartets exhibiting micronuclei varied with the monosomics.

B. Cytologic Investigations of Nullisomic Plants

Nullisomics are individuals deficient for one pair of chromosomes. They have been reported rarely and only in polyploid organisms.

In Nicotiana Tabacum, an allotetraploid with 24 pairs of chromosomes, all of the possible different monosomics but no nullisomics have been obtained Olmo (57), Clausen (18), Clausen and Cameron, (19). Similarly in seven different monosomics in Nicotiana rustica Lammerts (44) was unable to obtain nullisomic progenies. Since several types of 23-chromosome male gametes have proved partially functional the failure of nullisomics to appear in N. Tabacum and N. rustica is probably due primarily to inviability of nullisomic zygotes.

In common oats, Avena sativa, which is hexaploid, Huskins (35),

Smith, Huskins and Sander (80) found that homozygous B-type fatuoids (offtypes in common oats resembling Avena fatua) have only 20 pairs of chromosomes, these were obtained in the progeny of heterozygous fatuoids (20" + 1'). Philp (60, 61) isolated two additional nullisomics.

In common wheat, Triticum vulgare, nullisomics have been obtained by several investigators. Many of these deficiencies have evidently involved the same chromosome, the "C"(IX) or speltoid chromosome. Homozygous B-type speltoids (20") have been found in the progeny of monosomic "C"(IX) plants as has been shown by Huskins (36), Smith, Huskins and Sander (80) and Sears (71).

Nullisomics other than those involving chromosome "C"(IX) also have been isolated. Nullisomic dwarfs or semi-dwarfs have been obtained by Thompson (99) following a varietal cross in T. vulgare by Kihara (cited by Thompson, 99) among derivatives of T. polonicum x T. spelta and by Uchikawa (101). Love (48) found nullisomic plants and also nullisomic lines in 50 strains, in the F₅ to F₇, selected for various agronomic characters from hybrids of 4 varieties of T. vulgare x T. durum var. Tumillo. Most of the nullisomic lines were partially fertile.

The origin and characteristics of 7 nullisomics were described by Sears in 1941 at which time their possible usefulness for genetic analysis and breeding was also pointed out. Compared to normal (21") plants all the nullisomics were less vigorous and fertile, however, all were female fertile and 4 produced functional pollen. In 1944 Sears described 17 of the 21 possible nullisomics in Chinese. None were found to be completely sterile, ten or eleven were fertile as both male and female, five or six were female fertile only, and one was male fertile only. All the 21 nullisomics have now been obtained (sears, 76). Considerable progress has already been made in associating genes with chromosomes using nullisomics.

Because the A and B genome chromosomes of Triticum vulgare pair regularly with wheats of the emmer group (A and B genomes) a 34-chromosome hybrid of a monosomic plant of T. vulgare with a member of the emmer group will show at meiosis whether or not the univalent concerned is a chromosome homologous with one of emmer. The nullisomic were numbered I to XIV in the order they were obtained if the chromosome involved was homologous to a particular chromosome of the emmer or tetraploid wheats. Those nullisomics that corresponded to a particular chromosome of the C(D) genome of common wheat were numbered XV to XXI in the order in which they were obtained.

C. Cytologic Investigations of Plants with Telocentric Chromosomes and Isochromosomes

Telocentric chromosomes are aberrant chromosomes that are deficient for one whole arm and have a terminal centromere. Isochromosomes are chromosomes that are deficient for one arm but duplicated for the other. These aberrations have been observed in several plant species and certain types of anomalous behaviour have been noted where detailed studies have been carried out. Upcott (103) Koller (43) and Darlington (21) discovered that both telocentric chromosomes and isochromosomes arise through misdivision of univalents.

Rhoades (65), working with maize (Zea mays), found a telocentric chromosome consisting of the short arm of chromosome 5 to be unstable in somatic tissue, tending to be entirely lost or reduced in size. At pollen mitosis it occasionally gave rise to an isochromosome.

Love (47) working with the variety Dawson's Golden Chaff found 2 different off-type "mutants" each with 20 normal and 1 telocentric pair

of chromosomes. F_1 's of crosses between these 2 off-types exhibited 2 heteromorphic bivalents; this indicated that the telocentrics were fragments of two different chromosomes. One of the "mutants" was white chaffed indicating that the lost arm carried the gene for red chaff color in that variety. He described misdivision in wheat in subsequent papers (48, 49, 50). In the 1943 report he states that various isochromosomes in wheat frequently misdivide at Anaphase I when they are unpaired.

Smith (79) studied two fragments of a chromosome in Triticum monococcum L. ($2n = 14$) that apparently arose as the result of breakage at the centromere. The fragments were discovered in an individual offspring of a spike that had developed on a plant grown from an X-rayed dormant seed. The shorter of the two fragment chromosomes was a telocentric chromosome composed of one arm of one of the normal chromosomes and the longer fragment was an isochromosome for the other arm of the same chromosome. The fragments were rarely transmitted through the pollen and through less than half the eggs. He demonstrated the usefulness of such fragments in the study of linkage relations of genes and suggested a method for associating the fragments with other chromosomes (one at a time) by means of interchanges.

Most of the work with wheat on telocentric chromosomes and isochromosomes has dealt largely with derivatives of the "C" chromosome (IX in Sears series). Sears (72) found misdivision in microsporocytes of wheat at anaphase I which occurred at a frequency sufficient to account for the frequency of telocentrics and isochromosomes observed in the progeny of monosomic plants. Sanchez-Monge and Mac Key (66) reported that misdivision of univalents occurred mainly at the second meiotic division. Li, Hsia, and Lee (46) determined cytologically meiotic misdivision of both isochromosomes IX and telocentric chromosome IX. Sears (42) found only slight differences in the female transmission and frequencies

of misdivision of univalent iso- and telo- IX in comparison with normal IX, however, both iso- IX and telo- IX were somatically unstable. Smith, Huskins, and Sander (81) reported that the behavior of iso- IX was similar to normal IX. They also noticed that the isochromosome had a smaller tendency to be excluded at T II than did normal IX; a similar observation was made by Sanchez-Monge (cited by Sears, 74). Akerman and Mac Key (66) found the isochromosome of the long arm of chromosome IX paired with normal IX in 3% of the pollen mother cells while Smith, Huskins, and Sander (81) noticed similar pairing in 48% of the pollen mother cells. Huskins (37) found pairing of isochromosomes for long arm of IX with normal IX or with a homologous isochromosome to be quite variable but never exceeding 50%.

Misdivision of univalents at T I was observed by Darlington (21) in Fritillaria, Upcott (103) in Tulipa, and by Koller (43) in Pisum. Sears (74) found that misdivision of univalent at T I resulted in the production of both telocentrics and isochromosomes. Misdivision of univalents at T I may be grouped according to Sears (74) into 3 categories as follows: (a) One normal chromatid passes to one pole and the two arms of the other chromatid either pass separately to the other pole or one or the other remains acentric on the plate. (b) Two identical arms pass to one pole and the other two arms either go to the other pole or one or both remain acentric on the plate. (c) Three arms go to one pole and the fourth arm either passes to the opposite pole or remains on the plate. Sears (74) working with the variety Chinese observed misdivision of the univalent- IX at T I in 39.7% of microsporocytes as compared with a total frequency of only 1.7% in the variety used by Sanchez-Monge and Mac Key (66).

Misdivision of univalents at T II has been reported by Upcott (103) in Tulipa, Koller (43) in Pisum, and by Darlington (21) in Fritillaria.

Sears (74) reported that at T II as at T I univalent IX of Chinese showed a higher frequency of misdivision than did the variety univalents of Sanchez-Monge and Mac Key (66); at least 29.3% of the lagging univalents in Chinese misdivided (Sears, 74) while Sanchez-Monge and Mac Key (66) report 10.7% misdivision. Sanchez-Monge and Mac Key (67) grouped misdivision at T II into two classes: (a) the two halves of the centromere separate early and lead the way to the poles, and (b) the centromere is pulled apart after the two have been carried to opposite poles. Misdivision at T II according to Sears (74) involved some of the newly formed isochromosomes as well as normal chromosomes, however, there was a high frequency of loss of T II laggards. It was observed that there was no tendency for telocentrics to misdivide or to form isochromosomes at first microspore mitosis.

Genetic tests by Sears (74) showed that in 17.8% of the eggs in monosomics of chromosome IX which transmitted a chromosome IX or derivative it was an isochromosome or telocentric for the long arm which was transmitted.

Sears (75) found no differences in frequency of formation of isochromosomes among 16 independently produced telocentrics for the long arm of chromosome IX. He observed somatic loss of both telocentrics and isochromosomes for chromosome IX and other wheat chromosomes, with more frequent loss of the telocentric.

On the basis of the work of all these investigations the mode of origin of isochromosomes and telocentrics in common wheat seems fairly well established. At first meiotic division, both telocentrics and isochromosomes are produced from univalents. At the second meiotic division some of the isochromosomes are converted to telocentrics by a second misdivision. Additional telocentrics are formed by misdivision of some of the chromosomes which divided normally at first division.

According to Sears (74) it is possible that isochromosomes actually transmitted are produced by misdivision of telocentrics at some post meiotic division.

2. Breeding Behavior of Wheat Aneuploids

A. Nullisomics

The breeding behavior of nullisomics depends on the extent of egg and/or pollen fertility. Sears (71) reported that none of the 17 different nullisomics were completely sterile, 15 or 16 were female fertile, 10 or 11 were partially male fertile, and one was male fertile only. Nullisomic wheat plants, if at least partially male and female fertile produce only nullisomic offspring when selfed (Sears 76). Progeny of nullisomic -III, which is partially asynaptic (Sears 71), may include aneuploid types other than nullisomics. In crosses with normal (disomic) lines, nullisomics produce monosomics corresponding to the respective nullisomics; nullisomic -III is an exception because asynapsis causes it to give rise to a variety of aneuploid progeny when crossed with normals. Because of depressed vigor and fertility, it is usually impractical to use nullisomics in making crosses. Only nullisomic -I, Nullisomic -VII, and Nullisomic -XXI are maintained as nullisomics, and only nullisomics -VII and XXI are used in crosses (Sears 76). For the other 19 chromosomes monosomics, monotelosomics or mono-isosomics are used instead of nullisomics.

B. Monosomics

The breeding behavior of monosomics has been studied by Nishiyama (56), Huskins (37), Smith, Huskins, and Sander (81), Sears (71, 76), and

numerous other investigators. Monosomic plants when selfed produce disomic, monosomic, and nullisomic offspring in frequencies varying with the chromosome concerned (Sears 71, 76). Sears (71) found that female transmission of 20- chromosome gametes is approximately 75% regardless of the chromosome concerned because of irregular meiotic behavior and frequent elimination of the univalent chromosome at reduction division. Male transmission of the deficiency varies from approximately 1% for several nullisomics to approximately 10% for nullisomic -III (Sears, 76). The 21- chromosome male gametes account for from approximately 90% to 100% of the fertilizations presumably because competition favors the 21- chromosome gametes. When monosomic plants are used as females in crosses with normals approximately 75% of the offspring are monosomic, when used as males about 4% of the progeny are monosomic. Table I illustrates the breeding behavior of monosomic plants.

TABLE I

FREQUENCIES OF DISOMIC, MONOSOMIC, AND NULLISOMIC OFFSPRING EXPECTED IN F_2 FROM SELFING TYPICAL MONOSOMIC PLANTS, i.e. 4% TRANSMISSION OF 20- CHROMOSOME GAMETES THROUGH THE MALE, 75% THROUGH THE FEMALE.

Transmission through the female	Transmission through the male	
	21- chromosome pollen (n) 96%	20 chromosome pollen (n-1) 4%
21 chromosome eggs (n) 25%	21" plants (disomic) 24%	20" 1' plants (monosomic) 1%
20 chromosome eggs (n-1) 75%	20" 1' plants (monosomic) 72%	20" plants (nullisomic) 3%
Totals - 21" plants - 24%		
20" 1' plants - 73%		
20" plants - 3%		

C. Monotelosomics and Mono-isosomics

In the production of substitution lines ordinary monosomics cannot be used because of the possibility of obtaining monosomics deriving their univalent chromosome from the female instead of the male parent. However, if the male parent is allowed to self between successive backcrosses there would be no possibility for the monosomics to obtain their monosome from the female parent and monosomics could be used as females. Monosomics are available, having a telocentric chromosome or an isochromosome instead of a normal whole univalent chromosome, these can be cytologically recognized (Sears 71, 72, 76). The monotelosomics or mono-isosomics can safely be used in the development of substitution lines, Sears (76). Since the male and female transmission frequencies of telocentrics and isochromosomes are not yet known no definite F_2 ratios can be predicted for offspring of monotelosomics or mono-isosomics that are selfed. The F_2 's of selfed monotelosomics or mono-isosomics should, however, be composed of 3 types of individuals: (1) nullisomics

(11) monotelosomics or mono-isosomics

(111) di-telosomics ($20''$ + one pair of telocentric chromosomes) or di-isosomics ($20''$ + one pair of isochromosomes).

3. Cytogenetic Methods of Analysis in Common Wheat Using Aneuploids.

A. Absence of Genetic Effects in Nullisomics

This method of analysis can be used to locate dominant genes and certain types of recessive genes in any variety in which nullisomics have been established.

These genes can be located simply by observing the absence of their effect in the proper nullisomic. Sears (71) using nullisomic analysis in the variety Chinese located several dominant genes. A gene for red seeds was associated with chromosome XVI; the chromosome which is absent in nullisomic XVI. Nullisomic XVI produces seeds that are white. Two dominant awn inhibiting genes were found to be located on chromosomes VIII and X because of increased awn development in nullisomics VIII and X. Two awn promoting genes were found to be located on chromosomes II and XX - this was shown by the complete awnlessness of nullisomics II and XX. Sears (73) using nullisomics and working on the inheritance of the sphaerococcum gene in wheat showed that there is a class of dominants which cannot be located using nullisomics because the critical nullisomic still shows the dominant phenotype. In crosses of T. sphaerococcum with 17 different nullisomics of Chinese, no F_1 (all monosomic) was of the sphaerococcum type, although, the sphaerococcum gene must have been in the hemizygous condition since it was located on one of the 17 chromosomes tested. In F_2 families involving chromosome XVI, segregation was not at random, the disomics were sphaerococcum while monosomics resembled T. vulgare. The results show that the dominant allele of the sphaerococcum gene is carried by chromosome XVI of Chinese. There is, however, no tendency for Chinese nullisomic XVI to resemble T. sphaerococcum since two doses of the sphaerococcum gene are needed for development of this character, and the gene in the hemizygous state is relatively ineffective.

The corresponding type of recessive gene, if present in Chinese can be located by observation of nullisomics or monosomics. These recessive genes are ineffective in the hemizygous condition. Sears (71) located the recessive squarehead and speltoid-suppressing genes on chromosome IX by observing the absence of the characters in both mono-IX and nulli-IX.

These hemizygous-ineffective recessives express themselves only in double or greater dose.

B. F_2 Analysis of Monosomic F_1 's

Dominant, ordinary recessive, and hemizygous ineffective recessive genes can be studied in the F_2 populations.

If a simple dominant gene conditions a character, the critical F_2 family contains 1 to 10% of the plants with the recessive character. This deviation from the 3:1 ratio occurs because both disomic and monosomic plants carry the dominant gene(s) and only the nullisomic plants express the recessive form of the characteristic. Unrau (102) reported the location of two dominant genes using the F_2 method. The gene for red color of glumes in Federation 41 was found to be associated with chromosome I. One simple dominant gene in Hymar for dense spikes was associated with chromosome XX. Transgressive segregation indicated that at least 1 additional gene was modifying the degree of spike density. Sears (76), using F_2 analysis, reported that the pubescent-glumed gene in Indian was associated with chromosome XIV.

The F_2 method is also applicable to location of two or more complementary or duplicate genes located on different chromosomes. Clausen and Cameron (19, 20) located duplicate genes for chlorophyll production in Nicotiana Tabacum. Larson (45) in crosses of Chinese with S-615 using aneuploid analysis and relying mainly on F_2 data, associated four genes affecting stem solidness with chromosomes VIII, XIII, XIX, and XX. The gene for promoting solidness was associated with chromosome VIII and solidness inhibitor genes were associated with chromosomes XIII, XIX, and XX of Chinese. Unrau (102) located one of two duplicate genes for winter

THE UNIVERSITY OF CHICAGO
CHICAGO, ILL.

1911

TO THE EDITOR OF THE JOURNAL OF THE
ROYAL ANTHROPOLOGICAL INSTITUTE
SIR,
I have the honor to acknowledge the receipt of your letter of the 10th inst. in relation to the paper on the "Prehistoric Man of the Old World" which I have the pleasure to send you herewith. I am sorry that I cannot send you a copy of the paper at once, but it is not yet ready for the press. I am, however, sending you a copy of the proof, which I hope will be of some use to you. I am, Sir, very respectfully,
Yours truly,
J. H. R. KELLOGG
Professor of Anthropology
University of Chicago

habit of growth in Hymar with chromosome IX.

Duplicate or complementary genes carried by the same chromosome can be located by F_2 analysis. Sears and Rodenhiser (77) found that two dominant complementary genes for resistance of the variety Timstein to stem-rust race 56 were located on chromosome X. All the families, except the chromosome family, segregated approximately 9 (resistant) : 7 (susceptible). In F_2 populations of chromosome X, 122 plants were resistant and only 2 (presumably nullisomic) were susceptible.

C. F_3 Analysis

In this method, F_3 populations from selected disomic F_2 individuals are studied. Sears (76) discusses the use of the method in locating genes. He states that it may be advisable to use this method if it is not possible to score F_2 populations, or if it is desired to locate several genes requiring test procedures. In critical F_3 populations, all of the disomics will be homozygous for the gene under study, and the chromosome is then designated as the bearer of that gene or those genes. No genes have been located using this method.

D. Use of Chromosome Substitution Lines

(a) From other Wheat Varieties

The use of this method in locating genes has been discussed by Sears (71, 76). Sears (76) states that chromosome X of Timstein has been substituted for chromosome X of Chinese and that it was possible to establish that this chromosome controls resistance to everyone of the several rust races tested. This method of analysis was employed in studying the genetics

of characters reported on in this study; further discussion of the method, in common wheat, will follow the results in this report.

(b) Alien Chromosome Substitutions

O'Mara (58) studied the effect of substituting a specific Secale cereale chromosome for a specific Triticum vulgare chromosome. Nullisomic IX plants are completely male sterile, largely female sterile and weak. Adding the Secale chromosome in the disomic condition to nullisomic-IX, which is equivalent to substituting it for chromosome IX, restores male sterility, increases female fertility and improves plant vigor so that individuals appear normal. This effect is different from that of adding the bivalent to the normal T. vulgare complement which results in semi-dwarf partially female fertile plants. His observations show that effects of substitution cannot be predicted from addition.

Gerstel (28) discusses the mechanism of chromosome substitution in backcrosses of the N. Tabacum - N. glutinosa amphidiploid to N. Tabacum. It was found that Holmes substituted a chromosome from N. glutinosa, which carried genes for mosaic resistance, for one of N. Tabacum.

4. Genetics of Characters Involved in this Study.

A. Awning

Since the first genetic study on the inheritance of awning in common wheat hybrids was reported in 1905 by Biffen there has been lack of agreement amongst investigators on the genetics of awning. Monogenic, digenic, trigenic and tetragenic control of awning has been reported. Some of the reasons why there have been so many discrepancies in the results obtained may be due to (1) the use of different classification systems, (11) the crossing of material similar in phenotype but different in genotype and (111) the incorrect classification and grouping of individuals in segrega-

of numerous projects in the field of research and development in the field of science and technology, all of which are in the process of being carried out.

(b) The following projects are being carried out:

(1) The first project is the development of a new type of

machine which will be used for the purpose of testing the strength of materials.

(2) The second project is the development of a new type of machine which will be used for the purpose of testing the strength of materials.

(3) The third project is the development of a new type of machine which will be used for the purpose of testing the strength of materials.

(4) The fourth project is the development of a new type of machine which will be used for the purpose of testing the strength of materials.

(5) The fifth project is the development of a new type of machine which will be used for the purpose of testing the strength of materials.

(6) The sixth project is the development of a new type of machine which will be used for the purpose of testing the strength of materials.

(7) The seventh project is the development of a new type of machine which will be used for the purpose of testing the strength of materials.

(8) The eighth project is the development of a new type of machine which will be used for the purpose of testing the strength of materials.

(9) The ninth project is the development of a new type of machine which will be used for the purpose of testing the strength of materials.

(10) The tenth project is the development of a new type of machine which will be used for the purpose of testing the strength of materials.

(11) The eleventh project is the development of a new type of machine which will be used for the purpose of testing the strength of materials.

(12) The twelfth project is the development of a new type of machine which will be used for the purpose of testing the strength of materials.

(13) The thirteenth project is the development of a new type of machine which will be used for the purpose of testing the strength of materials.

(14) The fourteenth project is the development of a new type of machine which will be used for the purpose of testing the strength of materials.

(15) The fifteenth project is the development of a new type of machine which will be used for the purpose of testing the strength of materials.

(16) The sixteenth project is the development of a new type of machine which will be used for the purpose of testing the strength of materials.

(17) The seventeenth project is the development of a new type of machine which will be used for the purpose of testing the strength of materials.

(18) The eighteenth project is the development of a new type of machine which will be used for the purpose of testing the strength of materials.

(19) The nineteenth project is the development of a new type of machine which will be used for the purpose of testing the strength of materials.

(20) The twentieth project is the development of a new type of machine which will be used for the purpose of testing the strength of materials.

(21) The twenty-first project is the development of a new type of machine which will be used for the purpose of testing the strength of materials.

(22) The twenty-second project is the development of a new type of machine which will be used for the purpose of testing the strength of materials.

(23) The twenty-third project is the development of a new type of machine which will be used for the purpose of testing the strength of materials.

ting generations. Most authors have regarded the awnless or tip awned condition as being dominant to awned, however, the antithetical view has also been taken, Howard and Howard (39), Stewart (84), etc.

Monogenic ratios have been obtained by numerous investigators in crosses of awnletted or tip-awned with fully awned varieties, Ausemus (5), Biffen (6), Clark and Quisenberry (14), Gaines and Singleton (27), Goulden, Neatby and Walsh (30), Neatby and Goulden (53), Quisenberry (63), Quisenberry and Clark (64), Shen, Tai and Chang (78), Stewart (87), Stewart and Bischoff (88), Stewart and Dalley (89), Stewart and Tingey (94), Torrie (100), Swenson, Buchholtz and Grafuis (96).

The awnless condition was found to be dominant or incompletely dominant, also, the awned condition was never completely recessive. The F_1 plants of these crosses have awn tips distinctly longer than the awnletted or tip-awned parent but nearer to it than to the awned parent. The F_1 plants were not of exactly the same awn type in all these crosses. In some cases they had awn tips distinctly longer than those of awnletted or tip-awned parent and it was possible to classify F_2 into a 1:2:1 ratio. In others, the heterozygote could only be distinguished from the homozygous awnletted plants by their breeding behavior, and the F_2 was classified in the ratio 3 (awnletted) : 1 (awned).

Several workers have studied the genetics of completely awnless wheats. Digenic ratios have usually been obtained in crosses of awnless with tip-awned or completely awned varieties. Ausemus (5) reported that two factor pairs are involved in awn inheritance in the cross Hope (awned) x Supreme (awnless). Clark (9) in a cross of Kota (awned) x Hard Federation (awnless) explained inheritance on the basis of a dihybrid ratio in which 5 classes were studied and the short-awned and awned classes were shown to be recessive to the awnless, apically awnletted and awnletted classes. Clark,

Florell and Hooker (12) studied awn inheritance in crosses between Bobs (awnless) and Hard Federation (awnless) with Propo (awned). F_1 in both crosses was apically awnletted showing that awnlessness is dominant. The F_2 and F_3 segregated into 5 classes. A 9:7 two factor F_2 ratio was obtained in both crosses. Clark, Quisenberry and Powers (15) in a cross of Hope (awned) x Hard Federation (awnless) showed that 2 pairs of genes condition awning. Hope was postulated to have the genotype aabb and Hard Federation the genotype AABB. Love and Craig (51) reported a 15:1 ratio for tip-awned and awnless to awned in a cross between Sonora (awnletted) and other awnless varieties. The results indicated that Sonora carries a factor for awns. Quisenberry and Clark (64) made crosses of Sonora with Quality (awnletted), Supreme (awnless) and Reliance (awned). In the Sonora x Quality cross a complete range of segregation was obtained in the F_2 from awnless to awned. On the basis of F_2 and F_3 results it was assumed that each variety carried a dominant awn inhibiting gene and the genotype of Sonora was aaBB and Quality AAbb. In the Sonora x Supreme cross segregation in F_2 and F_3 indicated a single factor difference, Supreme was assumed to have the genotype AABB. From the cross Sonora x Reliance segregation could not be explained by a single gene difference, a minor gene appeared to be operating. Reliance genotype was assumed to be aabb. Stewart (84) in crosses between Federation and awned varieties as Sevier found that the 2 awn genes of Federation were linked with 35% c/o. In another Federation cross Stewart and Heywood (90) found the 2 genes for awnlessness segregating independently. Gfeller (29) studied awn inheritance in a Garnet x Red Fife cross; F_2 and F_3 results gave a dihybrid ratio of 5 awnless : 5 apically awned : 5 awnletted : 1 awned. The parents carry different genes which behave cumulatively in inhibiting awn expression. In a Hard Federation (awnless) x Kota (awned) cross,

Stewart and Judd (91) concluded on the basis of F_2 and F_3 results that 2 independently inherited gene pairs are responsible for awnedness. Kilduff (42) in a Kota x Garnet cross concluded that at least 2 gene pairs conditioned awning.

The work of Watkins and Ellerton (105), one of the most extensive studies conducted on the genetics of awning in wheat, shows three or possibly four main loci affecting length of awn. At one locus, B_1 and b_1^a reduce the awns to tip awns or half awns and are dominant to over the non-inhibitory allele, b_1 . At another locus are alleles B_2 and b_2 , similar in effect to B_1 and b_1 . A factor b_2^a or A, similar to b_1^a , seems to belong to this series but may lie at a separate locus. The Hd (hooded) factor reduces the awns and makes them twisted or curved. All these factors are in the A and B genomes. They postulated that either one of the 3 genes, B_1B_2 or A in the homozygous state produces tip-awns. If any 2 or all 3 of the genes are in the homozygous dominant state the plant is awnless. When all 3 genes are in the homozygous recessive state the plant is awned. There are several factors in addition to the ones described according to Watkins and Ellerton (105) which affect awn length to a greater or lesser degree. The main effect of these genes is on some other character, such as spike density or glume length.

Clark, Florell and Hooker (12) studied awning in crosses between awnless Bobs and Hard Federation with awned Propo. They stated that as many as 4 factor pairs are involved in the inheritance of awning.

Using nullisomic analysis in the variety Chinese Sears (71) located several genes affecting awning. Hd (hooded) was found to be located on chromosome VIII, B_2 was associated with chromosome X and b_1 with chromosome IX. Two awn promoting genes were associated with chromosomes II and XX. O'Mara (58) using deficiencies was able to associate 3 major awn inhibiting genes with chromosomes VIII, IX and X. In crosses of Chinese

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The third point is that the
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The fourth point is that the
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The sixth point is that the
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The seventh point is that the
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The eighth point is that the
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with Hymar (both almost awnless), Unrau (102) found that awning was conditioned by 3 genes. Chromosomes VIII and X of Hymar carried recessive alleles of the 2 dominant awn-inhibiting genes of Chinese. A dominant awn inhibiting gene with greater effect than either of the 2 Chinese awn inhibitors was associated with chromosome IX of Hymar. Unrau's results supplement the previous findings of Sears (71) and O'Mara (58). Heyne and Livers (34) using monosomic analysis studied awning in the variety, Pawnee. They proposed a series of "A" genes, in addition to the series already present, to explain awning in their crosses. An "A" gene is (hypothetically) incompletely dominant over an awn producing allele a. The recessive gene a in the homozygous condition could theoretically produce full awns if not inhibited by partially epistatic genes Hd or B₂. Assigning a₁ and a₂ to chromosomes II and XX of Chinese and assigning similar genes to chromosomes XII, XVI and XXI of Pawnee the genotypes of Chinese and Pawnee would be as follows: Chinese Hd(8) B₂(10) a₁(2) a₂(20) A₃(12) A₄(16) A₅(20) and Pawnee hd(8) b₂(10) a₁(2) a₂(20) a₃(12) a₄(16) a₅(21). From these studies it appears that chromosomes XII, XVI and XXI are involved in awn expression as well as chromosomes II, VIII, IX, X, and XX.

B. Earliness

Although most investigators claim earliness is governed by a complex factor relation, monogenic, digenic and trigenic inheritance has been reported.

Biffen (6) in an interspecific cross between Polish, an early wheat, and Rivet, a late wheat, reported that one factor pair governs the inheritance of earliness in wheat and that earliness was dominant. Florell (23)

crossed Marquis x Sunset (very early) and found that one factor pair is responsible for earliness. There was no genetical overstepping the early or late parental limits by any of the hybrid populations. Earliness showed dominance in the F_2 generation. Florell suggested the possible presence of a number of minor modifying gene pairs.

Nieves (54) in a cross of Kanred x Florence found the early heading date of Florence in F_1 to be dominant but in later generations to be intermediate. Three gene pairs conditioned earliness. Nieves (55) observed that the F_1 of Florence x Barletta headed on the same day as the early parent, Florence. In later generations segregation showed earliness to be controlled by 3 independent gene pairs.

Thompson (98) studied earliness in a number of spring varieties. F_1 plants matured with the late parents while the ranges in F_2 extended in all cases at least as far, in either direction, as the means of the 2 parents. Thompson (98) showed that multiple genes are concerned with earliness directly and in addition many factors may affect earliness indirectly i.e. a factor causing a short stem may cause a shorter ripening period. Transgressive segregation was observed in some F_3 families which were earlier than the early parent. Clark (9) reported that in a cross between Kota and Hard Federation earliness was dominant over lateness. Clark (10) reported on studies in crosses between Marquis and Hard Federation in which he found early heading partially dominant in F_2 . Transgressive segregation for lateness was shown in the F_3 . Harrington (32) in crosses between varieties of durum wheat concluded that multiple genes control inheritance of earliness. Clark and Hooker (13) reported that in the F_2 of Marquis x Hard Federation, early heading was partially dominant although no large early and no small late groups appeared. Stephens (83) studied earliness in 6 varieties of spring wheat. F_2 and F_3 data indicate that

earliness may be due to a number of independent multiple genes having a cumulative effect. In one of the crosses there was evidence of transgressive segregation as the extremes of both parents were exceeded. A study of earliness was made by Aamodt (1) in diallel crosses of Marquis, Kota and Kanred. Earliness was dominant to lateness. The data indicated that at least 2 gene pairs conditioned this character. It was suggested that the genotype of the late heading Marquis x Kanred hybrid would be AAbbccdd, when crossed to Marquis (probably AABBCCDD) the F_1 will be AABbCcDd. It would be an early spring type. The actual results in the F_2 , 15(early) : 1 (late) fitted fairly well the theoretical expectations according to the proposed hypothesis. Florell (24) studied earliness in the F_1 of the backcrossed generation in Quality (T. vulgare) x Jenkin (T. compactum) and in Jenkin x Little Club (T. compactum). It was found that probably 3 or more factors are responsible for the differences in earliness observed. Waldron (104) found Marquis significantly earlier than Kota. Selection 1656 and Ceres are both earlier than Marquis by an amount more significantly greater than Marquis is earlier than Kota. Selections made from 1656 indicate that in this selection there are at least 2 pure breeding transgressive segregates for earliness. On the basis of these results it was assumed Kota and Marquis to be separated by at least 4 pairs of alleles. Torrie (100) studied earliness in F_2 and F_3 generations of the crosses, Selection I-28-60 x Milturum, Reward x Caesium, and Caesium x Marquis. Multiple genes were found to control inheritance of earliness. A partial dominance of earliness was found in the crosses Reward x Caesium and Caesium x Marquis. Gfeller (29) reported that the F_1 of a cross between the early parent Garnet and the late parent Red Fife was intermediate in earliness. A unimodal F_2 segregation was obtained showing the presence of the action of many genes governing earliness.

Shen, Tai and Chang (78) studied earliness in a cross between a Chinese variety, Pathology 4592 and an Australian variety, Nebawa. Date of heading of F₁ plants covered practically the whole range of the 2 parents with a mean close to the early parent. A number of F₂ plants headed earlier than the early parent but no plants headed later than the late parent. F₃ results showed that some plants in at least 2 and possibly more lines were genotypically slightly later in heading than the late parent. The number of genes involved in the cross could not be determined with certainty but it was concluded that multiple genes with minute effects were involved. The early genes were found to be partially dominant over the late genes. The same authors in a cross of Prelude x Nanking 2905 obtained transgressive segregation.

Freeman (25) in a cross between durum and common wheat, found in the F₂ and F₃ that the average date of heading, while intermediate was nearer that of the late parent indicating that lateness is at least partially dominant. Bryan and Pressley (8) crossed Sonora and Turkey wheats and observed that the F₁ was intermediate in time of heading between the parents and the majority of the F₂ was inclined towards the late parent. They found that lateness was partially dominant.

C. Plant Height

Few investigations have been conducted on the genetics of plant height. Digenic as well as multigenic ratios for this character have been reported.

Nieves (54) reported that in the cross Kanred x Florence, tallness was dominant and bifactorial. Nieves (55) again reported on the genetics of plant height in 2 different crosses. In the Florence x Kanred cross, tallness introduced by Kanred was dominant as reported in 1936. It was suggested that two independent gene pairs controlled plant height.

In the Barletta x Florence cross, dwarfs appeared in certain F_2 families in the ratio 3:13. Barletta is thought provisionally to be doubly recessive and Florence doubly dominant for genes conditioning plant height. The results suggest the existence of a dominant N gene for tallness, which also acts as an inhibitor of E. All dwarf F_2 plants were sterile and the hypothesis could not be checked.

Freeman (25) in a durum common wheat cross found the F_1 hybrids taller than the tallest parent and a wide range of segregation for height was observed in the F_2 . There was greater variability in the shorter progenies indicating complex inheritance. Harrington (32) in Mindum x Pentad crosses found no F_3 lines exceeding Mindum (40.3") in height, but 6 lines were shorter than Pentad (34.6") indicating the presence of more than one pair of genes for height. Clark (9) in Kota x Hard Federation crosses found tallness to be partially dominant. He stated that tallness was due principally to heterosis and was easily affected by environmental conditions. Torrie (100) studied inheritance of plant height in F_2 and F_3 of three different crosses, Reward x Caesium, Caesium x Marquis, and Selction I-28-60 x Milturum. Tallness was shown to be partially dominant in the cross, Reward x Caesium. Polymeric factors were thought to control the inheritance of plant height.

D. Lodging

Few studies have been conducted on this quantitative character.

Harrington (32) studied lodging resistance in hybrid families of 2 Triticum durum crosses, namely: (1) Kubanka No. 8 x Pentad and (11) Mindum x Pentad. Kubanka and Pentad are very similar in erectness, their means both being 70%, Mindum averaged 80%. Transgressive segregation took

place in both crosses. Some Kubanka 8 x Pentad lines appeared to be less erect and others considerably more erect than either parental variety. Three F_3 Mindum x Pentad lines were lower than Pentad in % erectness, and 3 were higher than Mindum. The results of these crosses indicated that erectness is dependent on several heritable factors.

Kilduff (42) conducted genetic studies in F_2 , F_3 , and F_4 on the progeny of 2 common wheat crosses, Kota x Red Bobs and Kota x Garnet. Two main gene pairs appeared to condition the difference in straw strength between Kota and Garnet. The entire expression of straw strength, however, could best be explained on the basis of several gene pairs. Transgressive segregation in the direction of greater weakness of straw was noted.

Genetic studies by Torrie (100) were made in the F_3 and F_4 generations of the crosses, Reward x Caesium and Caesium x Marquis. The lodging index was used to obtain the straw strength of each line. Index was calculated by the formula:
$$\frac{\% \text{ plants lodged} \times \text{Average angle off the vertical}}{90}.$$

A partial dominance of strong straw was found in both crosses. On the basis of results obtained it was postulated that multiple genes apparently control the inheritance of straw strength.

E. Protein Content

Protein, a component of quality, has been studied fairly extensively. Both monogenic and multigenic control of protein content have been reported.

Worzella (106) reported the only case of monogenic control of protein content in hybrids originating from a soft red winter wheat cross involving the varieties Trumbull and American Banner.

Zinn (108) found crude protein content to be an inherent varietal

characteristic, since he obtained an interannual correlation coefficient of 0.38 in a study of 40 pure lines of wheat. Clark (10) obtained transgressive segregation for protein content beyond the upper extremes of both parents in the F_4 of reciprocal crosses of Kota x Hard Federation. Clark (10) studied inheritance of protein content in Marquis x Hard Federation and Hard Federation x Propo crosses. The F_2 hybrids of Marquis x Hard Federation were found to be intermediate with respect to the parents in protein content. The hybrids were nearer the parent of lower average protein content. F_2 and F_3 data indicated, as a whole, that crude protein content was inherited in degrees intermediate to the parents. Its mode of inheritance could not be determined. Protein content is easily affected by the environment and increased yield usually causes a decrease in protein content. In Hard Federation x Propo crosses, F_2 hybrids tended toward the low protein parent, Propo, indicating a dominance of the genes for low protein content. His data indicated that the inheritance of protein is very complex, and easily influenced by the environment. Clark and Smith (16) studied crude protein content inheritance in Nodak and Kahla durum wheat crosses. In comparison with the parents, crude protein content of F_3 strains was intermediate with an indication of transgressive segregation beyond that of the parents for both high and low protein content. Worzella (106) reported on crude protein content inheritance in crosses involving American Banner, Trumbull and Michikof. Results indicated that the mode of inheritance of crude protein content is conditioned by multiple genes. Hybrids were intermediate between the parents with lines varying in percent protein from the lower to the higher parent. Worzella and Cutler (107) found protein content to be definitely inherited in soft red winter wheat. The distribution of the hybrid populations formed a normal curve, suggesting that multiple genes controlled inheritance. Inheritance of protein content in crosses of Marquis and

Kota Spring wheats was reported on by Clark and Quisenberry (14). They found that in the F_2 and F_3 the average crude protein content was not significantly different from that of the lower protein, Marquis, parent. Several F_3 strains had a lower protein content than Marquis indicating transgressive segregation. Clark and Hocker (13) in reciprocal crosses of Marquis x Hard Federation found protein content for F_2 and F_3 of hybrids was intermediate between that of the parents and there was no indication of transgressive segregation. They state that protein content is inherited in intermediate degrees between the 2 parents by means of multiple genes. Correlations between the protein content of F_2 and F_3 were not significantly different, this illustrates how readily this character is influenced by the environment. Aamodt and Torrie (2) found inheritance of protein content in the Milturum x Selection I-28-60 cross to be controlled by multiple genes, whose exact nature was not determined. Clark, Florell and Hooker (12) in a series of crosses between Bobs, Hard Federation and Propo, found a tendency for low protein content to be dominant. Correlations between F_2 and F_3 were not significant. Multiple gene mode of inheritance was postulated which is in agreement with the results obtained by Clark and Hooker (13).

F. Spike Density

Although a few investigators report digenic and multigenic control of spike density, in general, simple segregation has been observed in genetic studies of this character.

Most investigators agree that one main gene is responsible for differentiating the dense spiked from lax spiked plants. Biffen (6) in crosses between Rivet x Polish, and Devon x Hedgehog obtained 1:2:1 and 3:1 segregation ratios respectively. Lax spikes appeared to be dominant

to dense spikes, Boshnakian (7) obtained ratios which approached 3 dense: 1 lax. The F_3 showed various degrees of density within the dense and lax forms. These variations were thought to be the result of segregation of modifiers or of additional density factors capable of producing density only within short ranges. Spike density was studied by Florell (24) in the crosses, Quality x Little Club, Quality x Jenkins, Jenkins x Hard Federation, and Jenkins x Marquis. A one factor difference between the club and lax types of a pike was found in the backcrosses of the 4 varietal combinations and the results were verified in the regular F_2 and F_3 generations. In the F_3 generations both club and lax segregates of different densities were observed. Minor genes evidently were present. Gaines (26) crossed numerous varieties and explained his ratios by assuming a one-factor difference. Schlehuber (68) in crosses Albit x Minhardi and Albit x Buffum reported a one gene 3:1 ratio for both crosses. Stewart (84) found a ratio of one dense to two heterozygous to one lax in his studies of spike density in wheat hybrids. He reported transgressive segregation for spike density in both directions and gives no genetic hypothesis. Similar results for spike density were obtained by Stewart in (85) and (86) and (87). Other investigations reporting segregation of spike density into simple 1:2:1 ratios were published by Stewart and Bischoff (88), Stewart and Heywood (90), Stewart and Price (93), Stewart and Woodward (95), Stewart and Dalley (89), and Stewart and Nelson (92). In most of these investigations transgressive segregation in both directions were observed. The results show that one or more minor factors modify the expression of the major gene.

Meyer (24), found a digenic difference in vulgare hybrids involving crosses between the fairly dense squarehead type of wheat and the lax long-spiked varieties. Elliott (22) also found the results of F_1, F_2, F_3 and

F_4 of *T. vulgare* (Sonora) x *T. compactum* (Club C.I. 4534) for spike density to be controlled by 2 genes. One gene inherited from Sonora, exerted a greater influence, while the gene from the Club parent seems to have a less marked effect upon the length of spike. Nieves (54) in the cross Kanred x Florence showed a 9:7 digenic ratio with transgression for spike density in the F_2 . In 1937 (Nieves) reported the results of a cross between Florence and Kanred, both medium dense. Forms denser than the parents appeared in the F_2 in the ratio 9:7, each variety appears to be homozygous for one of two independent dominant density genes.

Nilsson-Ehle in 1911, according to Hayes and Garber (33) studied spike density in crosses between compact and middense wheats. The F_2 segregated into compact, middense and lax forms. He assumed the dense form was of the genotype $CCL_1L_1L_2L_2$. The C gene was thought to inhibit the expression of the lengthening genes L_1 and L_2 and also to produce spikes with short internodes.

Unrau (102) in crosses between Chinese monosomics (lax) and Hymar (dense) associated the gene for spike density with chromosome XX. Transgressive segregation indicated that at least one additional gene was modifying the degree of density.

G. Thousand-Kernel Weight

Differences in thousand-kernel weight have been found to be definitely inherited. Monogenic, trigenic and multigenic inheritance has been reported.

Jasnowski (40) in crosses between three varieties of *T. vulgare* showed that three pairs of cumulative genes are concerned with the inheritance of grain weight. There was no correlation between weight of

grains and number of grains per spikelet or number of spikelets per spike but weight of spike was found to be dependent on weight of grain. Studies on the progeny of crosses (Jasnowski, 41) between Suska, Chinese, and Hildebrandt's indicated that three pairs of cumulative genes were involved. The genotypes of the varieties studied were designated thus: Suska aaBBcc, Chinese AAbbcc, Hildebrandt's AABBCC.

Worzella (106) reported that differences in thousand kernel weight in hybrids of American Banner x Trumbull appeared to be monogenically controlled.

Worzella and Cutler (107) studied thousand kernel weight in soft red winter wheat and found the characteristic to be definitely inherited. The distribution of the hybrid populations studied formed normal curves, and suggested multiple gene inheritance.

H. Yield

Yield has been found to be a definite heritable character. Its expression, however, is influenced to a large extent by environmental conditions.

Waldron (164) found yield of Ceres, a selection from a Marquis x Kota cross to be significantly higher than that of either parent. Ceres is a transgressive segregate with regard to yield, this effect was stated as being due to the additive effect of high yielding genes obtained from each parent. Clark and Smith (16) studied yield in F_2 and F_3 of Nodak x Kahla durum wheat crosses and found the yield of F_3 plants to be intermediate between the parents with certain F_3 strains showing transgressive segregation by exceeding the yield of the best parent checks. Their results showed partial dominance of high yield. Clark (9) states that

"yield may be considered as a character complex affected by environment and by most of the morphological and physiological characters of the plant". Yield appeared to be due to multiple genes in the Kota x Hard Federation cross. A partial dominance of the high yielding parent was obtained. Clark and Hooker (13) reported transgressive segregation for grain yield in a Marquis x Hard Federation cross. Similar results were obtained by Clark, Florell and Hooker (12) in crosses between Bobs, Hard Federation and Propo wheats. Clark, Quisenberry and Powers (15) studied yield inheritance and found partial dominance of high hield, also they reported transgressive segregation for inheritance of grain yields. Aamodt, Torrie and Wilson (3) in crosses between Reward and Milturum spring wheats observed that yield appeared to be of a complex nature. A partial dominance of low yielding genes was indicated. Torrie (100) studied yield inheritance in F_3 and F_4 in the cross Reward x Caesium and reported that multiple genes apparently control inheritance of grain yield. Low yield was observed to be partially dominant.

III. MATERIALS AND METHODS OF PROCEDURE

1. Description of Parental Varieties.

The substitution lines used in this study were established by E. R. Sears. Four varieties of common wheat were involved in the production of the 3 sets of substitution lines. Chinese was used as the recipient variety and 3 sets of substitution lines with chromosomes from the varieties Thatcher, Hope, and Timstein were produced in each of the 3 sets respectively.

A description of the varieties with respect to the characters studied is given below.

Variety				
Character	Chinese	Thatcher	Hope	Timstein
Awning	awnless	awnleted	awned	awnleted
Earliness	late	early to midseason	midseason	early
Density	3.17	2.21	2.15	1.91
Height	midtall	short to midtall	midtall	short
Lodging resistance	very susceptible	very resistant	medium to strong resistance	resistant
*Protein content	13.85%	14.90%	13.35%	13.25%
*Thousand-kernel weight	22.7 grams	31.3 grams	36.5 grams	35.6 grams
*Yield	473.8 grams per 4-row rod long plot	1013.8 grams per 4-row rod long plot	675.8 (1954) grams per 4-row rod long plot	957.9 grams per 4-row rod long plot

* Value given for characters in Chinese are averages from the 3 sets of substitution lines over the years 1953 and 1954.

* Values for each Thatcher character are averages for 1952, 1953, and 1954.

* Values for each Hope and Timstein character are averages for 1953 and 1954.

2. Experimental Methods

A. Production of Substitution Lines

To illustrate the procedure of chromosome substitution the transfer of chromosome I from Thatcher to Chinese will be outlined using (a) nullisomics and (b) monotelosomics or mono-isosomics.

(a) Procedure using nullisomics.

(i) Nullisomic I of Chinese used as the female parent is crossed with the variety to be tested (Thatcher).

Nullisomic - I (20") x Normal Thatcher (20" + 1")

gametes 20' x 21' \longrightarrow 20" + 1' (monosomic for Thatcher one chromosome).

(ii) The monosomic F_1 plants are next crossed, as males, to nullisomic - I. Because the monosomic plants produce two types of gametes, two types of progeny are produced. From the union of 20 chromosome male and female gametes nullisomic plants are produced. When 21 chromosome male gametes unite with 20 chromosome female gametes, monosomic backcross I progeny are produced. In these plants chromosome I of Thatcher will be present as a univalent. Approximately 90 - 99% of the offspring of a nullisomic (ϕ) x monosomic (σ^7) cross are monosomic. The reason for the high proportion of monosomic plants is that approximately 90 - 99% of the functioning pollen has 21 chromosomes.

	Nullisomic - I	x	Monosomic F_1 's	
gametes	20'	x	21' \longrightarrow 20" + 1' (Thatcher)	90 - 99%
	20'	x	20' \longrightarrow 20"	1 - 10%

(iii) The procedure in (b) is repeated for 5, 6, or more backcross generations to nullisomic - I of the recurrent parent variety, Chinese. By the fifth backcross generation approximately 97% of the genotype will be that of the recurrent parent other than chromosome I which will be

genetically as it was in the donor variety. Selfing of these fifth back-cross generation monosomics, as mentioned earlier, will result in approximately 24% of the progeny being disomic for chromosome I of Thatcher. These disomic (21") plants represent the substitution line, they may be increased and the line can be studied by comparing it to Chinese, Thatcher, and other substitution lines.

(b) Procedure using monotelosomics or mono-isosomics.

(i) Monotelosomic - I or mono-isosomic - I of Chinese used as the female parent is crossed with the variety to be tested (Thatcher).

Monotelosomic	x	Thatcher	
20' + telocentric	x	21' →	20" + (1' telocentric, heteromorphic pair)
gametes			
20'	x	21' →	20" + 1' (monosomic for chromosome I of Thatcher)
mono-isosomic	x	Thatcher	
20' + isochromosome	x	21' →	20" + (1' + isochromosome, heteromorphic pair).
gametes			
20'	x	21' →	20" + 1' (monosomic for chromosome I of Thatcher).

(ii) The monosomic F_1 plants are next crossed ^{as} /males to Chinese monotelosomics or mono-isosomics. Because monotelosomics, mono-isosomics and monosomics each produce two types of gametes, four types of individuals are possible in the progeny.

monotelosomic - I	x	monosomic F_1 's	
20' + telocentric,	x	20' →	20" + telocentric
20'	x	20' →	20"
gametes			

20' + telocentric	x	21' →	20'' + (1' telocentric, heteromorphic pair).
20'	x	21' →	20'' + 1' (monosomic for chromo- some I of Thatcher).
mono-isosomic - I	x	monosomic F ₁ 's	
20' + isochromosome	x	20' →	20'' + telocentric
20'	x	20' →	20''
20' + telocentric	x	21' →	20'' + (1' isochromosome, hetero- morphic pair).
20'	x	21' →	20'' + 1' (monosomic for chromosome I of Thatcher).

(iii) The procedure in (ii) is repeated for 5, 6, or more backcross generations to monotelosomic - I or mono-isosomic - I of the recurrent parent variety, Chinese. Remainder of procedure is similar to that of (iii) in nullisomic procedure.

Throughout the entire program of chromosome substitution the chromosomal constitution of the plants is determined cytologically by examination of pollen mother cells.

Monosomics cannot be used as females in the backcrossing program unless each backcross is interrupted by a generation of selfing. If they are used two types of monosomics are possible in the backcross program; those receiving the univalent from the male and those receiving it from the female parent. Differentiation would be impossible unless the chromosomes carried genes for some character that could be identified. Monotelosomics and mono-isosomics are available and these are used instead of the ordinary monosomics.

B. Experimental Design of Field Experiments

A randomized blocks design of 4 replicates for each substitution line with the recipient and donor varieties as checks, was used at Edmonton.

In 1952 only substitution lines involving Thatcher were available, but in 1953 and 1954 the additional substitution lines involving Hope and Timstein also were included.

At Brooks, Alberta, where experiments were conducted in 1954 only, each of the 3 sets of substitution lines were tested in a 6-replicate balanced lattice design.

Plots were comprised of 4 rows 18.5 feet long and spaced 9 inches apart. At Edmonton individual plots were separated by 2 rows of winter wheat so that lodging could be more easily and correctly estimated.

C. Methods of Collecting Data

Awning was studied in all 3 sets of substitution lines. Four classes, depending on the extent of awn development, were employed: 1) awnless, 2) awnletted, if short awnlets were present, 3) apically awned, if short awnlets were present near the base of the spike and the length of awns increased towards the apex, usually the upper half being almost fully awned, 4) awned, when the spike was fully awned.

Date of heading, used as an indication of earliness, was recorded separately for each plot. The material in a plot was considered headed when approximately 75 - 80% of the leading spikes had just emerged from the boot. Heading of plants in individual plots was extremely uniform, which greatly facilitated recording these data.

Plant height, determined shortly before maturity, was recorded as the height of plants in inches from the ground to the top of the spike. The heights of 15 plants selected at random were averaged for each plot.

Spike density was determined for the leading spikes of 15 different plants in each plot. The average spike density was calculated by dividing the number of spikelets per spike by spike length. The length of the

spike was measured from the base of the rachis node to the tips of the uppermost spikelet not including the awns. All nodes were counted to give the true number of spikelets.

The average 1,000-kernel weight, in grams, of each line was obtained by averaging the weights from three random 200-kernel samples. The 1,000 kernel weights were calculated from a bulk sample for each line.

Lodging resistance was recorded at intervals during a period from approximately 4 weeks after heading to maturity. An average value for each plot was obtained from 6 observations.

A scoring range of 1-10 was used, with plants standing erectly being scored 1, those showing an inclination of approximately 20 degrees were scored 3-4 while plots completely lodged were given a score of 10.

Yield in grams per plot was obtained on the 2 centre rod long (16.5') rows of each plot.

Protein content was determined on random samples from each substitution line. The nitrogen content was determined using the Kjeldahl method, on 2 1-to 1½-gram ground samples from each random sample. The values of the 2 determinations were averaged and multiplied by 4.93 to give the percent protein content.

D. Statistical Analyses Of Data

Analyses of variance were computed on the data for thousand-kernel weight, yield, earliness, height, spike density, protein content, and lodging for each set of substitution lines. The character, awning, was not analyzed statistically.

IV. EXPERIMENTAL RESULTS

1. Awning

Data on the effects of whole chromosome substitutions on awning in each of the three sets of substitution lines are summarized in Table 2.

Excluding the parents, three types of awn expression were found in the three sets of substitution lines. Illustrations of these awn types along with those of the recipient and donor varieties for each set are given in Figures 1, 2, 3, and 4.

With the exception of chromosomes VIII and X there is no effect on awning by substitution of Hope chromosomes for those of the variety Chinese. Chromosomes VIII and X of Hope do, however, affect the development of apically awned plants in the recipient variety. This is as would be expected on the basis of results obtained by Watkins and Ellerton (105) who postulated $HdHdb_1b_1B_2B_2$ as the genic formula for Chinese, and Sears (71) and Unrau (102) who have shown that in Chinese Hd and B_2 , two sets of dominant genes which are carried on chromosomes VIII and X respectively, reduce awn development, but do not entirely inhibit it. On this basis, then, it follows that Hope must carry the recessive alleles for increase of awn development on chromosomes VIII and X. Further, since substitution line IX is awnless as is the recipient variety Chinese it can be assumed that similar alleles are carried on this chromosome by both varieties. The question of the action of apparently recessive genes for awn development must be considered. These genes can conceivably produce phenotypic effects; they may promote awn development or they may have no effect at all. If the latter is true then the absence of awn inhibitors at the homologous or any other loci permits the expression of awns. On the basis of these results and the hypothesis stated the following genotypes and corresponding phenotypes represent the genetics of awning in this material:

TABLE 2

AWNING OF THATCHER, HOPE, TIMSTEIN, CHINESE AND THATCHER,
HOPE, AND TIMSTEIN SETS OF SUBSTITUTION LINES.

Chromosome tested	Thatcher set	Hope set	Timstein set
Thatcher	awnletted		
Hope		awned	
Timstein			awnletted
Chinese	awnless	awnless	awnless
1	awnless	awnless	awnless
2	awnless	awnless	awnless
3	apically awned	awnless	apically awned
4	apically awned	awnless	awnless
5	awnless	awnless	awnless
6	awnless	awnless	awnless
7	awnless	awnless	awnless
8	awnletted	apically awned	apically awned
9	awnletted	awnless	awnless
10	apically awned	apically awned	apically awned
11	awnless	awnless	awnless
12	apically awned	awnless	awnless
13	awnless		
15	awnless	awnless	awnless
16	awnless	awnless	awnless
17		awnless	awnless
18	awnless	awnless	awnless
19	awnless	awnless	awnless
20	awnless	awnless	awnless
21	apically awned	awnless	awnless

Chinese HdHd (VIII) b_1b_1 (IX) B_2B_2 (X) awnless because of genes Hd and B_2 ;
 Hope hdhd (VIII) b_1b_1 (IX) b_2b_2 (X) awned because of absence of awn inhibiting
 genes; Chinese VIII Hope hdhd (VIII) b_1b_1 (IX) B_2B_2 (X) apically awned;
 Chinese IX Hope HdHd (VIII) b_1b_1 (IX) B_2B_2 (X) awnless and same genotype
 as Chinese; Chinese X Hope HdHd (VIII) b_1b_1 (IX) b_2b_2 (X) apically awned
 because of only one inhibitor.

When chromosomes III, VIII, and X of the awnletted variety Timstein
 are substituted for their respective homologous in Chinese the substitution
 lines carrying these chromosomes exhibit apical awnedness. The remaining
 sixteen substitution lines tested are as awnless as the recipient variety.
 Since both Chinese VIII Timstein and Chinese X Timstein show apical
 awnedness it seems that both chromosomes VIII and X of Timstein carry
 the recessive alleles hd and b_2 respectively. Chinese IX Timstein is,
 like the recipient variety, awnless and on the basis of this and the fact
 that Timstein is awnletted and carries the alleles hd and b_2 , it is
 assumed that chromosome IX of Timstein carries the allele B_1 . However
 it could carry another allele slightly less effective, B_1^a . On the basis
 of these assumptions the genotypes of Timstein and substitution lines
 would be as follows: Timstein, $hdhdB_1B_1b_2b_2$ or $hdhdB_1^aB_1^ab_2b_2$; substitution
 line VIII, $hdhdb_1b_1B_2B_2$; substitution line IX, $HdHdB_1B_1B_2B_2$ or $HdHdB_1^aB_1^a$
 B_2B_2 ; and substitution line X, $HdHdb_1b_1b_2b_2$.

The results obtained in the set of Chinese lines with substituted
 Thatcher chromosomes were more difficult to interpret. Seven of the nine-
 teen Thatcher chromosomes tested expressed awning. Chromosome III, IV, XII,
 and XXI substitution lines were apically awned and chromosome lines VIII
 and IX were awnletted the remaining twelve lines were awnless. On the
 basis of awn type it is assumed that Thatcher chromosome VIII carries
 either of two alleles, hd or Hd^a and chromosome IX carries the allele b_1^a .
 Chinese line X was apically awned as in the previous two sets and it seems



Figure 1. Awn types of Thatcher, Chinese, Chinese VIII Thatcher, Chinese IX Thatcher, and Chinese X Thatcher.

- A. Spikes from awnleted Thatcher.
- B. Spikes from awnless Chinese.
- C. Spikes from apically awned Chinese VIII Thatcher.
- D. Spikes from awnleted Chinese IX Thatcher.
- E. Spikes from apically awned Chinese X Thatcher.

that Thatcher chromosome X carries the recessive allele b_2 . The genotypes with respect to chromosomes VIII, IX, and X, for Thatcher and Chinese substitution lines, eight, nine and ten are as follows: Thatcher, $hdhdb_1^a b_1^a b_2 b_2$ or $Hd^a Hd^a b_1^a b_1^a b_2 b_2$; substitution line eight, $hdhdb_1 b_1 B_2 B_2$ or $Hd^a Hd^a b_1 b_1 B_2 B_2$; substitution line nine, $HdHdb_1^a b_1^a B_2 B_2$; and substitution line ten, $HdHdb_1 b_1 b_2 b_2$.

The results from the three sets of substitution lines for chromosomes VIII, IX, and X substantiated previous findings. The appearance of awn types in lines carrying chromosomes III, IV, XII, and XXI of Thatcher and III of Timstein were not expected on the basis of published information. Because genes on the above four chromosomes affect awning a new hypothesis or an extension of the old one is necessary to explain the results obtained.

It is assumed that either hd or b_2 or both together are epistatic to genes on chromosomes III, IV, XII, and XXI and that Hd or B_2 or both together are non epistatic or only partially epistatic to genes on chromosomes III, IV, XII, and XXI which may be designated $K_1 K_2 K_3$ and K_4 respectively. The hypothesis holds whether the genes on III, IV, XII, and XXI are dominant or recessive. There may be more than one gene per chromosome, the assumption is made that only one gene affecting awning is present on each of the above chromosomes. We may take chromosome III of Timstein to demonstrate the hypothesis. In the donor parent genes on chromosome III are inhibited by hd and b_2 . When chromosome III is substituted into Chinese the action of genes on the transferred chromosome is not inhibited because Chinese possesses Hd and B_2 and the substitution line is awned. The same explanation would hold for genes on chromosomes III, IV, XII, and XXI of Thatcher.

On the basis of this hypothesis the genotypes for Chinese, Thatcher, Timstein, and Chinese substitution lines 3, 4, 12, and 21 would be as follows:

(1) If awning genes on chromosomes III, IV, XII, and XXI are recessive

	III	IV	VIII	IX	X	XII	XXI
Chinese	K_1K_1	K_2K_2	HdHd Hd ^a Hd ^a or	b_1b_1	B_2B_2	K_3K_3	K_4K_4
Thatcher	k_1k_1	k_2k_2	hdhd	$b_1^a b_1^a$ $B_1^a B_1^a$ or	b_2b_2	k_3k_3	k_4k_4
Timstein	k_1k_1	K_2K_2	hdhd	$B_1^a B_1^a$	b_2b_2	K_3K_3	K_4K_4
Subst. line 3	k_1k_1	K_2K_2	HdHd	b_1b_1	B_2B_2	K_3K_3	K_4K_4
subst. line 4	K_1K_1	k_2k_2	HdHd	b_1b_1	B_2B_2	K_3K_3	K_4K_4
subst. line 12	K_1K_1	K_2K_2	HdHd	b_1b_1	B_2B_2	k_3k_3	K_4K_4
subst. line 21	K_1K_1	K_2K_2	HdHd	b_1b_1	B_2B_2	K_3K_3	k_4k_4

(11) If awning genes on chromosomes III, IV, XII, and XXI are dominant.

	III	IV	VIII	IX	X	XII	XXI
Chinese	k_1k_1	k_2k_2	HdHd Hd ^a Hd ^a or	b_1b_1	B_2B_2	k_3k_3	k_4k_4
Thatcher	K_1K_1	K_2K_2	hdhd	$b_1^a b_1^a$ $B_1^a B_1^a$ or	b_2b_2	K_3K_3	K_4K_4
Timstein	K_1K_1	k_2k_2	hdhd	$B_1^a B_1^a$	b_2b_2	k_3k_3	k_4k_4
Subst. line 3	K_1K_1	k_2k_2	HdHd	b_1b_1	B_2B_2	k_3k_3	k_4k_4
subst. line 4	k_1k_1	K_2K_2	HdHd	b_1b_1	B_2B_2	k_3k_3	k_4k_4
subst. line 12	k_1k_1	k_2k_2	HdHd	b_1b_1	B_2B_2	K_3K_3	k_4k_4
subst. line 21	k_1k_1	k_2k_2	HdHd	b_1b_1	B_2B_2	k_3k_3	K_4K_4

It is believed that this or some other multiple gene theory is necessary to explain the occurrence of awn types in so many different substitution lines.

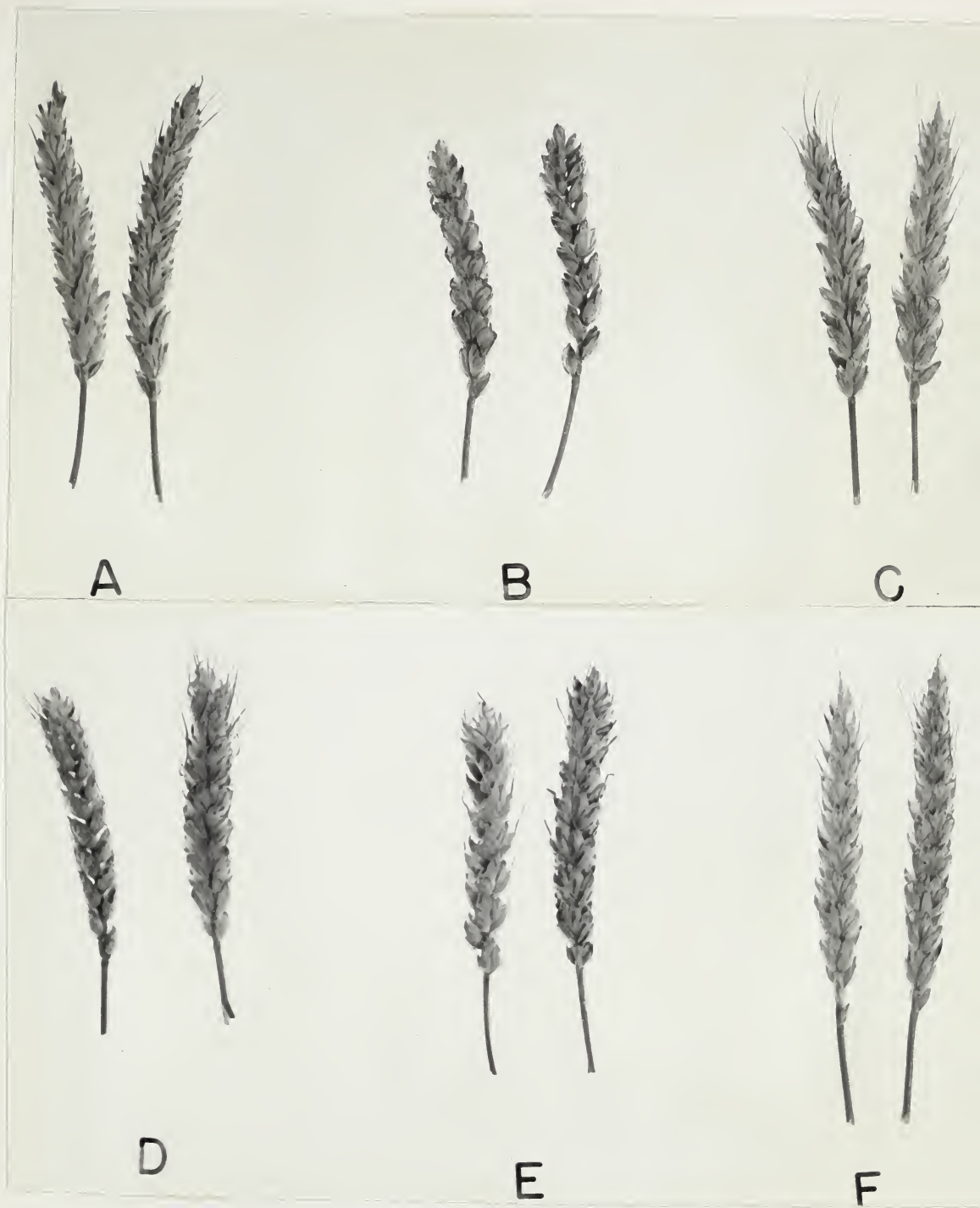


Figure 2. Awn types of Thatcher, Chinese, Chinese III Thatcher, Chinese IV Thatcher, Chinese XII Thatcher, and Chinese XXI Thatcher.

- A. Spikes from awnleted Thatcher.
- B. Spikes from awnless Chinese.
- C. Spikes from apically awned Chinese III Thatcher.
- D. Spikes from apically awned Chinese IV Thatcher.
- E. Spikes from apically awned Chinese XII Thatcher.
- F. Spikes from apically awned Chinese XXI Thatcher.



Figure 3. Awn types of Hope, Chinese, Chinese VIII Hope, and Chinese X Hope.

- A. Spikes from awned Hope.
- B. Spikes from awnless Chinese.
- C. Spikes from apically awned Chinese VIII Hope.
- D. Spikes from apically awned Chinese X Hope.



Figure 4. Awn types of Timstein, Chinese, Chinese III Timstein, Chinese VIII Timstein, and Chinese X Timstein.

- A. Spikes from awnleted Timstein.
- B. Spikes from awnless Chinese.
- C. Spikes from apically awned Chinese III Timstein.
- D. Spikes from apically awned Chinese VIII Timstein.
- E. Spikes from apically awned Chinese X Timstein.

2. Earliness

Data on earliness in Thatcher, Chinese and Chinese lines with substituted Thatcher chromosomes are summarized in Table 3.

On the basis of the results obtained the genes on 11 of the 19 chromosomes tested, have definite and measurable effects on earliness. The effects, on earliness, of substituted Thatcher chromosomes may be divided into three classes if it is assumed that differences in earliness exceeding the 5% level are those caused by genetic effects. The chromosome classes are: (a) those hastening significantly earliness of the recipient variety, (b) those the same as or similar to Chinese, and (c) those depressing significantly the earliness of Chinese.

Thatcher chromosomes having the same or similar effect as their homologs in Chinese are IV, XI, XVI, XIX, and XXI. The interpretation of results for these chromosomes may follow either of two alternatives: (a) the genes of Thatcher are similar to those of Chinese, or (b) neither Thatcher nor Chinese carry genes, affecting earliness, on these chromosomes.

Ten Thatcher chromosomes significantly hastened earliness of the recipient variety. The degree of hastening varied with the gene or genes on the individual chromosomes. Chromosome XV hastened earliness of Chinese by approximately 1 to $1\frac{1}{2}$ days. Chromosome II, V, VII, and VIII lines were approximately 4 to $4\frac{1}{2}$ days earlier than Chinese. The most striking effects were those of chromosome lines I, III, VI, and XII which produced heading 5 to $5\frac{1}{2}$ days earlier than Chinese. These differences signify that some chromosomes have major and others minor genetic effects on this character.

The action of substitution lines Chinese IX Thatcher and Chinese X Thatcher is more difficult to assess, since these lines were more variable in their action than other chromosome lines. Chromosome IX hastened heading by 3 to 5 days except in 1954 at Brooks where it was only one day earlier.

Since the conditions at Brooks may have tended to minimize differences Thatcher IX gene or genes may be interpreted as hastening earliness. Thatcher chromosome X line was more variable than Thatcher IX line and no definite effect can be attributed to gene(s), if present, on this chromosome.

The behavior of Chinese lines carrying Thatcher chromosomes XIII and XVIII is most striking. Throughout most of the summer of each year of testing these lines behaved as true or almost true winter wheats and headed approximately 20 to 25 days later than Chinese. The behavior of Chinese XIII Thatcher was not as true as that of Chinese XVIII in that it segregated to a small extent for earlier plants. It is possible that the few early plants in this line may actually be mechanical mixtures, however, genetic segregation of hybridization with other Chinese lines or other varieties is possible. The few earlier plants do resemble Chinese in headtype, which would probably rule out hybridization with other varieties.

The genetic explanation for Thatcher chromosomes XIII and XVIII is probably as follows: Chinese on chromosomes XIII and XVIII carries dominant, spring-growth-habit genes, while in Thatcher the recessive alleles for winter habit are present on chromosomes XIII and XVIII. It has been observed that monosomic XVIII of Chinese produces considerably later heading than does disomic Chinese. When chromosome XVIII of Chinese is exchanged for chromosome XVIII from Thatcher, plants with near winter-growth-habit result.

The genetic interpretation for the results obtained may be as follows: The genes of Thatcher may be divided into two types: (a) those differentiating summer and winter growth habit, as on chromosomes XIII and XVIII, and (b) those that modify the expression of genes in (a) to a greater or lesser extent. These modifiers are not all equal in effect (Table 3);



A

B

Figure 5. Photograph showing comparative earliness of Chinese and Chinese VII Hope.

- A. Chinese VII Hope, headed in 60 days.
- B. Chinese, headed in 67 days.

some appear to have major and others only minor modifying effects. Chromosomes I, III, VI, and XII are of the former type and chromosome XV the latter type.

Thatcher is earlier than Chinese even though it seems to carry the recessive alleles on XIII and XVIII for winter or near winter growth habit. Though the answer is unknown it seems that Thatcher possesses a larger number of both strong and weak alleles for earliness than does Chinese (10 Thatcher chromosomes hasten Chinese heading). Chromosomes I, II, III, V, VI, VII, VIII, IX, and XII are very strong modifiers and XV is a weaker modifier. The cumulative action of all these genes in Thatcher causes it to head earlier than Chinese.

Data on earliness in Hope, Chinese, and Chinese lines with substituted Hope chromosomes are summarized in Table 4.

Following a classification system similar to that used for the Thatcher set of substitution lines Hope chromosomes may be divided into two classes: (a) those the same as or similar to Chinese in earliness, and (b) those significantly earlier than Chinese.

The former class includes the gene or genes on Hope chromosomes I, VI, VIII, XI, XV, XXI, XVII, XIX, and XX. The explanations are similar to those for the lines which were non-significantly different from Chinese in Thatcher set of substitution lines.

The remaining 10 chromosomes hastened heading significantly. The most striking results were obtained with Chinese VII Hope line. This Hope chromosome hastened earliness of Chinese by approximately 10 days and the heading transgressed that of the earlier donor variety Hope. Chromosomes II, III, IX, X, XII, XVIII, and XXI hastened heading by 6 to 7 days. Chromosomes IV and V had less effect, their respective lines were significantly earlier by approximately 4 days, than Chinese. These

results show that different Hope chromosomes like those of Thatcher have unequal effects on this character (Table 4).

Data on earliness in Timstein, Chinese, and Chinese lines with substituted Timstein chromosomes are summarized in Table 5.

If it is assumed that differences in earliness exceeding the 5% level are caused by genetic effects of substituted chromosomes, two classes may be assumed (a) those producing effects the same as or similar to Chinese, (b), those producing types significantly earlier than Chinese.

Chromosome I, X, XI, XV, XVI, and XXI lines showed no significant difference in heading from Chinese. They either carry no alleles or are genetically the same as the recipient variety.

Chinese VIII Timstein and Chinese XII Timstein produced the most striking results, heading 4 to 5 days earlier than Chinese. Timstein chromosomes V, VI, and XVIII appear to possess weaker enhancing genes than VIII and XII, the respective lines headed approximately $3\frac{1}{2}$ days earlier than Chinese. The group of chromosomes comprising II, III, IV, VII, IX, XVII, XIX, and XX produced minor effects, hastening earliness by approximately $1\frac{1}{2}$ to 3 days over Chinese.

Since chromosome XI and XVI lines in all three sets were not significantly different from Chinese the inference may be that these chromosomes do not carry any genes affecting this character rather than possessing similar alleles. Chromosome XII of all 3 donor parents seems to possess the same allele(s). Chinese lines possessing this chromosome from the different parents hastened heading by 5 to 6 days.

That some of the homologous chromosomes of different varieties have different genetic effects is substantiated by the high significance of the lines x varieties interaction as shown in Tables 2 and 3 of the Appendix. The chromosomes having different effects are I, II, III, IV,

VI, VII, VIII, IX, X, XIX, and XXI. Taking chromosome VII as an example we see that Chinese VII Hope heads in 56.5 days whereas Chinese VII of Thatcher and Timstein head in 62.0 and 64.8 days respectively. Either a multiple allelic series for single genes are operating or chromosomes possess various combinations of same or different number of genes with or without differential alleles.

Earliness of individual lines was consistent from year to year as shown by the non-significance of lines x years interaction (Table 1 of the Appendix).

Average days of head of Chinese and Chinese lines with substituted Thatcher, Hope, and Timstein chromosomes in 1953 and 1954 are summarized in Table 6.

On the basis of these data two types of genes, as previously mentioned, are operating. The modifiers on different chromosomes are of unequal effect. Thatcher, Hope, and Timstein possess 10, 10, and 12 of these respectively. Thatcher apparently carries winter growth habit genes on chromosomes XIII and XVIII, Hope and Timstein possess summer growth habit genes on these chromosomes.

Table 3

DAYS TO HEAD OF THATCHER, CHINESE, AND CHINESE LINES WITH
SUBSTITUTED THATCHER CHROMOSOMES

Chromosome tested	1952	1953	1954	1954	Average
Chinese	69.00	66.25	65.00	67.50	66.93
Thatcher	63.00	61.00	54.00	58.70	59.18
1	64.25	63.00	57.50	61.80	61.64
2	66.00	64.00	58.50	62.50	62.75
3	64.00	63.00	57.00	62.00	61.50
4	68.00	66.25	63.50	68.10	66.46
5	66.00	64.00	59.00	62.80	62.95
6	64.75	63.00	57.00	62.50	61.81
7	66.00	63.75	58.50	63.30	62.88
8	65.25	63.50	58.00	62.00	62.18
9	64.00	63.00	61.00	66.80	63.70
10	66.00	66.00	62.50	67.30	65.45
11	68.75	66.75	65.00	67.70	67.05
12	64.25	63.00	57.00	61.70	61.48
13		77.75	90.00	88.00	85.25
15	66.00	65.50	63.50	66.00	65.25
16	72.00	66.25	64.00	66.50	67.18
18		83.00	90.00	88.00	87.00
19	68.00	66.75	62.50	66.50	65.94
20	66.25	64.00	60.50	65.50	65.93
21	68.50	66.00	62.50	65.30	65.58
L.S.D. - 5% level	0.42	0.52	1.36	0.48	1.61
1% level	0.57	0.69	1.85	0.76	2.14

Table 4

DAYS TO HEAD OF HOPE, CHINESE, AND CHINESE LINES WITH
SUBSTITUTED HOPE CHROMOSOMES

Chromosome tested	1953	1954	1954	Average
Hope	* 67.00	55.00	62.00	61.33
Chinese	66.75	65.25	67.00	66.33
1	66.50	63.75	66.10	65.45
2	64.25	55.00	62.00	60.41
3	62.25	53.75	61.80	59.27
4	64.75	59.00	62.50	62.08
5	64.50	58.25	62.30	61.68
6	64.50	61.00	65.00	63.50
7	60.00	50.00	59.80	56.60
8	65.25	63.75	66.00	65.00
9	62.25	53.00	62.00	59.08
10	62.25	53.50	61.80	59.18
11	66.75	63.00	67.10	65.61
12	63.75	55.50	62.10	60.45
15	65.50	61.75	66.80	64.68
16	66.50	62.75	67.10	65.45
17	66.25	61.75	66.10	64.70
18		58.50	61.70	60.10
19	* 73.00	64.75	67.00	68.25
20	65.00	65.00	66.70	65.56
21	63.75	55.25	61.70	60.23
* germinated approximately 8 days later than other lines				
L.S.D. - 5% level	1.77	1.75	1.61	4.07
1% level	2.25	2.20	1.95	5.44

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Author	Title	Year	Volume	Page
1.1	1.1.1	1.1.1	1.1.1	1.1.1
2.1	2.1.1	2.1.1	2.1.1	2.1.1
3.1	3.1.1	3.1.1	3.1.1	3.1.1
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98.1	98.1.1	98.1.1	98.1.1	98.1.1
99.1	99.1.1	99.1.1	99.1.1	99.1.1
100.1	100.1.1	100.1.1	100.1.1	100.1.1

Table 5

DAYS TO HEAD OF TIMSTEIN, CHINESE, AND CHINESE LINES WITH
SUBSTITUTED TIMSTEIN CHROMOSOMES

Chromosome tested	1953	1954	1954	Average
Timstein	60.00	51.00	56.80	55.93
Chinese	66.25	65.25	67.30	66.27
1	65.75	65.00	67.10	65.95
2	66.50	60.00	64.50	63.67
3	64.50	62.00	66.60	64.37
4	65.50	63.50	66.50	65.17
5	64.50	60.75	63.00	62.75
6	63.25	61.25	63.10	62.53
7	65.25	62.75	66.10	64.70
8	64.00	60.25	62.10	62.12
9	68.25	62.00	65.10	65.11
10	* 70.00	62.25	65.80	66.02
11	66.00	63.00	67.30	65.43
12	62.75	59.50	62.00	61.42
15	67.25	64.75	67.10	66.37
16	66.25	66.00	67.10	66.45
17	65.00	63.00	65.60	64.53
18	65.25	61.25	62.60	63.03
19	65.50	63.25	66.00	64.92
20	63.50	62.25	64.50	63.42
21	67.00	65.75	67.10	66.61

* germinated approximately 5 days later than other lines

L.S.D. - 5% level	0.98	1.02	1.16	1.09
1% level	1.31	1.36	1.54	2.88

TABLE I
Summary of the results of the experiments on the effect of the concentration of the solution on the rate of the reaction

Experiment	Concentration of the solution	Rate of the reaction	Time taken for the reaction to complete	Remarks
1	0.1M	0.05	10	Normal
2	0.2M	0.10	5	Normal
3	0.3M	0.15	3	Normal
4	0.4M	0.20	2	Normal
5	0.5M	0.25	1	Normal
6	0.6M	0.30	1	Normal
7	0.7M	0.35	1	Normal
8	0.8M	0.40	1	Normal
9	0.9M	0.45	1	Normal
10	1.0M	0.50	1	Normal
11	0.1M	0.05	10	Normal
12	0.2M	0.10	5	Normal
13	0.3M	0.15	3	Normal
14	0.4M	0.20	2	Normal
15	0.5M	0.25	1	Normal
16	0.6M	0.30	1	Normal
17	0.7M	0.35	1	Normal
18	0.8M	0.40	1	Normal
19	0.9M	0.45	1	Normal
20	1.0M	0.50	1	Normal
21	0.1M	0.05	10	Normal
22	0.2M	0.10	5	Normal
23	0.3M	0.15	3	Normal
24	0.4M	0.20	2	Normal
25	0.5M	0.25	1	Normal
26	0.6M	0.30	1	Normal
27	0.7M	0.35	1	Normal
28	0.8M	0.40	1	Normal
29	0.9M	0.45	1	Normal
30	1.0M	0.50	1	Normal
31	0.1M	0.05	10	Normal
32	0.2M	0.10	5	Normal
33	0.3M	0.15	3	Normal
34	0.4M	0.20	2	Normal
35	0.5M	0.25	1	Normal
36	0.6M	0.30	1	Normal
37	0.7M	0.35	1	Normal
38	0.8M	0.40	1	Normal
39	0.9M	0.45	1	Normal
40	1.0M	0.50	1	Normal
41	0.1M	0.05	10	Normal
42	0.2M	0.10	5	Normal
43	0.3M	0.15	3	Normal
44	0.4M	0.20	2	Normal
45	0.5M	0.25	1	Normal
46	0.6M	0.30	1	Normal
47	0.7M	0.35	1	Normal
48	0.8M	0.40	1	Normal
49	0.9M	0.45	1	Normal
50	1.0M	0.50	1	Normal
51	0.1M	0.05	10	Normal
52	0.2M	0.10	5	Normal
53	0.3M	0.15	3	Normal
54	0.4M	0.20	2	Normal
55	0.5M	0.25	1	Normal
56	0.6M	0.30	1	Normal
57	0.7M	0.35	1	Normal
58	0.8M	0.40	1	Normal
59	0.9M	0.45	1	Normal
60	1.0M	0.50	1	Normal
61	0.1M	0.05	10	Normal
62	0.2M	0.10	5	Normal
63	0.3M	0.15	3	Normal
64	0.4M	0.20	2	Normal
65	0.5M	0.25	1	Normal
66	0.6M	0.30	1	Normal
67	0.7M	0.35	1	Normal
68	0.8M	0.40	1	Normal
69	0.9M	0.45	1	Normal
70	1.0M	0.50	1	Normal
71	0.1M	0.05	10	Normal
72	0.2M	0.10	5	Normal
73	0.3M	0.15	3	Normal
74	0.4M	0.20	2	Normal
75	0.5M	0.25	1	Normal
76	0.6M	0.30	1	Normal
77	0.7M	0.35	1	Normal
78	0.8M	0.40	1	Normal
79	0.9M	0.45	1	Normal
80	1.0M	0.50	1	Normal
81	0.1M	0.05	10	Normal
82	0.2M	0.10	5	Normal
83	0.3M	0.15	3	Normal
84	0.4M	0.20	2	Normal
85	0.5M	0.25	1	Normal
86	0.6M	0.30	1	Normal
87	0.7M	0.35	1	Normal
88	0.8M	0.40	1	Normal
89	0.9M	0.45	1	Normal
90	1.0M	0.50	1	Normal
91	0.1M	0.05	10	Normal
92	0.2M	0.10	5	Normal
93	0.3M	0.15	3	Normal
94	0.4M	0.20	2	Normal
95	0.5M	0.25	1	Normal
96	0.6M	0.30	1	Normal
97	0.7M	0.35	1	Normal
98	0.8M	0.40	1	Normal
99	0.9M	0.45	1	Normal
100	1.0M	0.50	1	Normal

Table 6

AVERAGE DAYS TO HEAD OF CHINESE AND CHINESE LINES WITH
SUBSTITUTED THATCHER, HOPE, AND TIMSTEIN CHROMOSOMES
IN 1953 AND 1954

Chrom. tested	THATCHER			HOPE			TIMSTEIN			THAT- CHER	HOPE	TIMS- TEIN	LINES
	1953	1954	1954 ²	1953	1954	1954 ²	1953	1954	1954 ²				
Chinese	66.0	65.0	68.0	67.0	65.0	67.0	66.0	65.0	67.5	66.3	66.3	66.2	66.3
1	63.0	62.5	62.0	66.5	63.5	66.0	66.0	65.0	67.5	62.5	65.3	66.2	64.7
2	64.0	58.5	63.5	64.0	55.0	62.0	67.5	61.0	64.5	62.0	60.3	64.3	62.2
3	63.0	57.0	62.0	62.0	53.5	61.5	64.5	62.5	66.5	60.7	59.0	64.4	61.4
4	66.5	63.5	68.5	65.5	58.5	63.0	65.5	63.5	66.5	66.2	62.3	65.1	64.6
5	64.0	59.0	63.0	64.5	58.0	62.5	63.5	61.0	63.0	62.0	61.7	62.5	62.1
6	63.0	57.0	62.5	64.0	61.0	65.0	63.5	61.0	62.0	60.8	63.3	62.1	62.1
7	63.5	58.5	64.0	60.0	50.0	59.5	65.0	62.5	67.0	62.0	56.5	64.8	61.1
8	63.0	58.0	63.0	65.0	63.5	66.0	64.0	61.0	61.5	61.3	64.8	62.1	62.8
9	63.0	61.0	67.5	62.0	53.0	62.0	68.0	62.5	64.5	63.8	59.0	65.0	62.7
10	66.0	62.5	68.0	62.0	53.0	61.5	70.0	62.0	66.0	65.5	58.9	66.0	63.4
11	66.5	65.0	68.0	67.5	62.5	67.0	66.0	62.5	67.0	66.5	65.7	65.1	65.8
12	63.0	57.0	62.0	63.5	55.5	63.0	63.0	60.0	62.0	60.7	60.7	61.7	61.0
15	66.0	63.5	66.5	66.0	61.5	67.0	67.0	64.5	67.5	65.3	64.8	66.3	65.5
16	66.0	64.0	66.0	66.5	63.0	67.5	66.0	66.0	67.5	65.3	65.7	66.5	65.9
19	66.5	62.5	67.0	73.0	64.5	67.0	65.5	63.5	66.0	65.3	68.2	65.0	66.2
20	64.0	60.5	66.0	65.0	64.5	66.5	63.5	62.5	64.5	63.5	65.3	63.5	64.1
21	66.0	62.5	66.0	64.0	55.5	61.5	67.0	65.5	67.0	64.8	60.3	66.5	63.9
L.S.D. - 5% level	--	--	--	1.33	--	--	--	--	--	--	2.00	--	3.31
1% level	--	--	--	1.75	--	--	--	--	--	--	2.65	--	4.45

3. Plant Height

Data on plant height for each set of substitution lines are summarized in Tables 7, 8, and 9.

Plant heights of individual lines were consistent from year to year as shown by the non-significance of the lines x years interaction (Table 14 of the Appendix). It may, therefore, be assumed that differences among substitution lines are largely genetical.

Assuming that differences in plant height exceeding the 5% level of significance are caused by genetic effects of substituted chromosomes three phenotypic classes may be assumed:

- (a) height significantly greater than Chinese,
- (b) height the same as or similar to Chinese; and
- (c) height significantly less than Chinese.

	Significantly greater than Chinese	Same of similar to Chinese	Significantly less than Chinese
Thatcher	XI	I, II, III, IV, V, VII, IX, X, XII, XIII, XV, XVIII, XIX, XX, XXI.	VIII, XVI
Hope		II, IV, V, VI, X, XI, XV, XVI, XVII, XIX, XX, XXI.	I, III, VII, VIII, IX, XII.
Timstein		I, II, III, IV, V, VI, VII, IX, X, XI, XII, XV, XVI, XVII, XVIII, XIX, XX, XXI.	VIII

Only line Chinese XI Thatcher was significantly taller than Chinese. It appears that in Thatcher this chromosome carries the strongest

2. Data

Tests on plant height for each set of experimental lines

are presented in Table 1, 2, 3, 4.

From height of parental lines and combining cross

in this set of lines the following results are obtained:

Table 1: A 2x2 factorial. It was observed that the

differences among the parental lines and the

combinations were significant in plant height.

Level of significance was tested by means of analysis of variance

and the results are presented in Table 2.

(a) Height (cm) of parental lines and

(b) Height (cm) of combinations of parental lines

(c) Height (cm) of combinations of parental lines

Parental lines	Combinations of parental lines	Height (cm)
1. 100.0	1. 100.0	100.0
2. 100.0	2. 100.0	100.0
3. 100.0	3. 100.0	100.0
4. 100.0	4. 100.0	100.0
5. 100.0	5. 100.0	100.0
6. 100.0	6. 100.0	100.0
7. 100.0	7. 100.0	100.0
8. 100.0	8. 100.0	100.0
9. 100.0	9. 100.0	100.0
10. 100.0	10. 100.0	100.0
11. 100.0	11. 100.0	100.0
12. 100.0	12. 100.0	100.0
13. 100.0	13. 100.0	100.0
14. 100.0	14. 100.0	100.0
15. 100.0	15. 100.0	100.0
16. 100.0	16. 100.0	100.0
17. 100.0	17. 100.0	100.0
18. 100.0	18. 100.0	100.0
19. 100.0	19. 100.0	100.0
20. 100.0	20. 100.0	100.0
21. 100.0	21. 100.0	100.0
22. 100.0	22. 100.0	100.0
23. 100.0	23. 100.0	100.0
24. 100.0	24. 100.0	100.0
25. 100.0	25. 100.0	100.0
26. 100.0	26. 100.0	100.0
27. 100.0	27. 100.0	100.0
28. 100.0	28. 100.0	100.0
29. 100.0	29. 100.0	100.0
30. 100.0	30. 100.0	100.0
31. 100.0	31. 100.0	100.0
32. 100.0	32. 100.0	100.0
33. 100.0	33. 100.0	100.0
34. 100.0	34. 100.0	100.0
35. 100.0	35. 100.0	100.0
36. 100.0	36. 100.0	100.0
37. 100.0	37. 100.0	100.0
38. 100.0	38. 100.0	100.0
39. 100.0	39. 100.0	100.0
40. 100.0	40. 100.0	100.0
41. 100.0	41. 100.0	100.0
42. 100.0	42. 100.0	100.0
43. 100.0	43. 100.0	100.0
44. 100.0	44. 100.0	100.0
45. 100.0	45. 100.0	100.0
46. 100.0	46. 100.0	100.0
47. 100.0	47. 100.0	100.0
48. 100.0	48. 100.0	100.0
49. 100.0	49. 100.0	100.0
50. 100.0	50. 100.0	100.0

and the results are presented in Table 3.

It was observed that the

height increasing genes. Some of the other chromosomes may also have the same or similar effects as chromosome XI only that the corresponding homologues in Chinese carry the same alleles and therefore height is unaltered.

In the group of chromosomes that are the same as or similar to Chinese in height, it is quite likely there either are no effective genes for this character in these chromosomes, or if there are, they have similar effects.

Since the donor varieties Timstein, Thatcher, and Hope are shorter than Chinese on the average by 9.15, 2.52, and 0.3 centimeters respectively, the majority of the lines deviating significantly from Chinese should be shorter. The results conform to expectations. Chinese lines possessing chromosome VIII from all 3 donor varieties were significantly shorter than Chinese. Other lines similar in effect to chromosome VIII were: Chinese XVI Thatcher, Chinese I Hope, Chinese III Hope, Chinese VII Hope, Chinese IX Hope, and Chinese XII Hope. The genetic effects of these chromosomes appear to be the same or similar as shown when lines are compared using the respective L.S.D.'s.

Significant height transgression beyond the limits of both parents was observed in the Thatcher set and beyond Hope, the shorter parent, in the Hope set of substitution lines.

That some homologous chromosomes of the donor varieties have different genetic effects is substantiated by the significant lines x varieties interaction within years as shown in Tables 15 and 16 of the Appendix. The chromosomes having different effects are III, V, VI, VII, IX, X, XII, and XVIII. Taking chromosome XII as an example, we see that Chinese XII Hope is 41.9 inches tall, Chinese XII Thatcher is 50.0 inches tall, and Chinese XII Timstein is 42.3 inches tall. If the

chromosomal effect is due to one gene then there appears to be a multiple allelic series operating for each of the genes on the above chromosomes and these account for the highly significant differences among Chinese lines possessing homologous chromosomes from different donor varieties. Therefore, whether a chromosome from a particular variety will increase or decrease height will depend on the particular allele it carries in relation to the one present in Chinese. However, if the effect of a chromosome is due to more than one gene and a multiple allelic series exists for each, then the problem of determining the number of genes acting becomes extremely complicated.

Data on average plant heights of Chinese and Chinese lines with substituted Thatcher, Hope, and Timstein chromosomes in 1953 and 1954, together with L.S.D.'s for (a) lines within sets within years, (b) lines within sets, and (c) lines over sets and years, are given in Table 10.

It seems clear from the data that some chromosomes have major and others minor genetic effects. A multiple allelic series appears to exist, or else is simulated by combinations of two or more genes, for some of the chromosomes. In any event, eight chromosomes affected plant height significantly; chromosome XI of Thatcher was associated with significant height increase and chromosomes I, III, VII, IX, XII of Hope, XVI of Thatcher and VIII of all 3 donor varieties with significant height decreases. Therefore, at least eight genes or groups of genes affect this quantitative character.

Table 7

PLANT HEIGHT OF THATCHER, CHINESE, AND CHINESE LINES
WITH SUBSTITUTED THATCHER CHROMOSOMES

Chromosome tested	1952	1953	1954	Average
Thatcher	44.00	39.80	42.50	42.10
Chinese	43.75	41.00	49.10	44.62
1	45.00	40.90	48.70	44.87
2	43.25	40.30	48.40	43.98
3	45.00	41.70	50.00	45.57
4	43.75	40.10	49.20	44.35
5	43.50	40.60	47.80	43.97
6	44.75	42.70	52.30	46.58
7	43.25	40.20	46.80	43.42
8	40.25	38.80	44.90	41.32
9	41.75	40.90	50.20	44.28
10	43.50	40.70	49.80	44.67
11	45.75	42.00	52.70	46.82
12	44.25	42.40	50.00	45.55
13		41.20	49.90	45.55
15	43.75	41.40	49.40	44.85
16	39.50	40.30	48.00	42.60
17	45.50	41.30		43.40
18		41.80	49.30	45.55
19	44.25	41.40	50.90	45.52
20	43.25	40.70	49.40	44.45
21	42.50	41.00	50.00	44.50
L.S.D. - 5% level	1.09	1.40	4.97	2.06
1% level	1.44	1.87	6.74	2.77

Table 8

PLANT HEIGHT OF HOPE, CHINESE, AND CHINESE LINES
WITH SUBSTITUTED HOPE CHROMOSOMES

Chromosome tested	1953	1954	Average
Hope	42.7	47.1	44.90
Chinese	41.1	49.3	45.20
1	42.3	50.0	41.15
2	41.0	46.7	43.85
3	40.0	44.6	42.30
4	41.4	48.4	44.90
5	40.6	47.1	43.85
6	40.9	48.4	44.65
7	39.6	43.3	41.45
8	39.4	43.5	41.45
9	38.7	43.3	41.00
10	41.1	46.0	43.55
11	40.5	49.2	44.85
12	41.2	43.4	42.30
15	40.1	47.4	43.75
16	41.7	50.6	46.15
17	40.9	49.2	45.05
18		50.3	50.30
19	42.5	50.1	46.30
20	41.6	49.9	45.75
21	42.5	49.5	46.00
L.S.D. - 5% level	1.37	4.86	2.87
1% level	1.82	6.46	3.92

Table 1

Summary of the results of the analysis of variance for the effect of the treatment on the response variable.

Treatment	SS	df	MS	F	Prob > F
Control	1.00	1	1.00	1.00	.318
T1	1.00	1	1.00	1.00	.318
T2	1.00	1	1.00	1.00	.318
T3	1.00	1	1.00	1.00	.318
T4	1.00	1	1.00	1.00	.318
T5	1.00	1	1.00	1.00	.318
T6	1.00	1	1.00	1.00	.318
T7	1.00	1	1.00	1.00	.318
T8	1.00	1	1.00	1.00	.318
T9	1.00	1	1.00	1.00	.318
T10	1.00	1	1.00	1.00	.318
T11	1.00	1	1.00	1.00	.318
T12	1.00	1	1.00	1.00	.318
T13	1.00	1	1.00	1.00	.318
T14	1.00	1	1.00	1.00	.318
T15	1.00	1	1.00	1.00	.318
T16	1.00	1	1.00	1.00	.318
T17	1.00	1	1.00	1.00	.318
T18	1.00	1	1.00	1.00	.318
T19	1.00	1	1.00	1.00	.318
T20	1.00	1	1.00	1.00	.318
T21	1.00	1	1.00	1.00	.318
T22	1.00	1	1.00	1.00	.318
T23	1.00	1	1.00	1.00	.318
T24	1.00	1	1.00	1.00	.318
T25	1.00	1	1.00	1.00	.318
T26	1.00	1	1.00	1.00	.318
T27	1.00	1	1.00	1.00	.318
T28	1.00	1	1.00	1.00	.318
T29	1.00	1	1.00	1.00	.318
T30	1.00	1	1.00	1.00	.318
T31	1.00	1	1.00	1.00	.318
T32	1.00	1	1.00	1.00	.318
T33	1.00	1	1.00	1.00	.318
T34	1.00	1	1.00	1.00	.318
T35	1.00	1	1.00	1.00	.318
T36	1.00	1	1.00	1.00	.318
T37	1.00	1	1.00	1.00	.318
T38	1.00	1	1.00	1.00	.318
T39	1.00	1	1.00	1.00	.318
T40	1.00	1	1.00	1.00	.318
T41	1.00	1	1.00	1.00	.318
T42	1.00	1	1.00	1.00	.318
T43	1.00	1	1.00	1.00	.318
T44	1.00	1	1.00	1.00	.318
T45	1.00	1	1.00	1.00	.318
T46	1.00	1	1.00	1.00	.318
T47	1.00	1	1.00	1.00	.318
T48	1.00	1	1.00	1.00	.318
T49	1.00	1	1.00	1.00	.318
T50	1.00	1	1.00	1.00	.318
T51	1.00	1	1.00	1.00	.318
T52	1.00	1	1.00	1.00	.318
T53	1.00	1	1.00	1.00	.318
T54	1.00	1	1.00	1.00	.318
T55	1.00	1	1.00	1.00	.318
T56	1.00	1	1.00	1.00	.318
T57	1.00	1	1.00	1.00	.318
T58	1.00	1	1.00	1.00	.318
T59	1.00	1	1.00	1.00	.318
T60	1.00	1	1.00	1.00	.318
T61	1.00	1	1.00	1.00	.318
T62	1.00	1	1.00	1.00	.318
T63	1.00	1	1.00	1.00	.318
T64	1.00	1	1.00	1.00	.318
T65	1.00	1	1.00	1.00	.318
T66	1.00	1	1.00	1.00	.318
T67	1.00	1	1.00	1.00	.318
T68	1.00	1	1.00	1.00	.318
T69	1.00	1	1.00	1.00	.318
T70	1.00	1	1.00	1.00	.318
T71	1.00	1	1.00	1.00	.318
T72	1.00	1	1.00	1.00	.318
T73	1.00	1	1.00	1.00	.318
T74	1.00	1	1.00	1.00	.318
T75	1.00	1	1.00	1.00	.318
T76	1.00	1	1.00	1.00	.318
T77	1.00	1	1.00	1.00	.318
T78	1.00	1	1.00	1.00	.318
T79	1.00	1	1.00	1.00	.318
T80	1.00	1	1.00	1.00	.318
T81	1.00	1	1.00	1.00	.318
T82	1.00	1	1.00	1.00	.318
T83	1.00	1	1.00	1.00	.318
T84	1.00	1	1.00	1.00	.318
T85	1.00	1	1.00	1.00	.318
T86	1.00	1	1.00	1.00	.318
T87	1.00	1	1.00	1.00	.318
T88	1.00	1	1.00	1.00	.318
T89	1.00	1	1.00	1.00	.318
T90	1.00	1	1.00	1.00	.318
T91	1.00	1	1.00	1.00	.318
T92	1.00	1	1.00	1.00	.318
T93	1.00	1	1.00	1.00	.318
T94	1.00	1	1.00	1.00	.318
T95	1.00	1	1.00	1.00	.318
T96	1.00	1	1.00	1.00	.318
T97	1.00	1	1.00	1.00	.318
T98	1.00	1	1.00	1.00	.318
T99	1.00	1	1.00	1.00	.318
T100	1.00	1	1.00	1.00	.318

Table 9

PLANT HEIGHT OF TIMSTEIN, CHINESE, AND CHINESE LINES
WITH SUBSTITUTED TIMSTEIN CHROMOSOMES

Chromosome tested	1953	1954	Average
Timstein	36.2	35.4	35.80
Chinese	41.2	48.7	44.95
1	41.5	50.3	45.90
2	41.5	49.3	45.40
3	40.3	48.1	44.20
4	40.4	49.8	45.10
5	43.2	50.4	46.80
6	41.3	47.8	44.55
7	41.3	48.5	44.90
8	38.5	44.9	41.70
9	41.8	47.5	44.65
10	40.8	48.7	44.75
11	42.4	50.6	46.50
12	40.4	47.6	44.00
15	40.1	48.1	44.10
16	40.5	49.2	44.85
17	40.8	50.5	45.65
18	40.7	47.9	44.30
19	43.4	50.5	46.95
20	39.6	46.7	43.15
21	43.1	50.6	46.85
L.S.D. - 5% level	1.76	4.68	3.07
1% level	2.34	6.22	4.18

TABLE 1. Summary of the results of the analysis of variance for the effect of the treatment on the response of the subjects to the test.

Treatment	Mean	Standard Error	Significance
10.0	4.00	0.40	0.05
20.0	7.00	0.50	0.01
30.0	9.00	0.60	0.01
40.0	11.00	0.70	0.01
50.0	13.00	0.80	0.01
60.0	15.00	0.90	0.01
70.0	17.00	1.00	0.01
80.0	19.00	1.10	0.01
90.0	21.00	1.20	0.01
100.0	23.00	1.30	0.01
110.0	25.00	1.40	0.01
120.0	27.00	1.50	0.01
130.0	29.00	1.60	0.01
140.0	31.00	1.70	0.01
150.0	33.00	1.80	0.01
160.0	35.00	1.90	0.01
170.0	37.00	2.00	0.01
180.0	39.00	2.10	0.01
190.0	41.00	2.20	0.01
200.0	43.00	2.30	0.01
210.0	45.00	2.40	0.01
220.0	47.00	2.50	0.01
230.0	49.00	2.60	0.01
240.0	51.00	2.70	0.01
250.0	53.00	2.80	0.01
260.0	55.00	2.90	0.01
270.0	57.00	3.00	0.01
280.0	59.00	3.10	0.01
290.0	61.00	3.20	0.01
300.0	63.00	3.30	0.01
310.0	65.00	3.40	0.01
320.0	67.00	3.50	0.01
330.0	69.00	3.60	0.01
340.0	71.00	3.70	0.01
350.0	73.00	3.80	0.01
360.0	75.00	3.90	0.01
370.0	77.00	4.00	0.01
380.0	79.00	4.10	0.01
390.0	81.00	4.20	0.01
400.0	83.00	4.30	0.01
410.0	85.00	4.40	0.01
420.0	87.00	4.50	0.01
430.0	89.00	4.60	0.01
440.0	91.00	4.70	0.01
450.0	93.00	4.80	0.01
460.0	95.00	4.90	0.01
470.0	97.00	5.00	0.01
480.0	99.00	5.10	0.01
490.0	101.00	5.20	0.01
500.0	103.00	5.30	0.01
510.0	105.00	5.40	0.01
520.0	107.00	5.50	0.01
530.0	109.00	5.60	0.01
540.0	111.00	5.70	0.01
550.0	113.00	5.80	0.01
560.0	115.00	5.90	0.01
570.0	117.00	6.00	0.01
580.0	119.00	6.10	0.01
590.0	121.00	6.20	0.01
600.0	123.00	6.30	0.01
610.0	125.00	6.40	0.01
620.0	127.00	6.50	0.01
630.0	129.00	6.60	0.01
640.0	131.00	6.70	0.01
650.0	133.00	6.80	0.01
660.0	135.00	6.90	0.01
670.0	137.00	7.00	0.01
680.0	139.00	7.10	0.01
690.0	141.00	7.20	0.01
700.0	143.00	7.30	0.01
710.0	145.00	7.40	0.01
720.0	147.00	7.50	0.01
730.0	149.00	7.60	0.01
740.0	151.00	7.70	0.01
750.0	153.00	7.80	0.01
760.0	155.00	7.90	0.01
770.0	157.00	8.00	0.01
780.0	159.00	8.10	0.01
790.0	161.00	8.20	0.01
800.0	163.00	8.30	0.01
810.0	165.00	8.40	0.01
820.0	167.00	8.50	0.01
830.0	169.00	8.60	0.01
840.0	171.00	8.70	0.01
850.0	173.00	8.80	0.01
860.0	175.00	8.90	0.01
870.0	177.00	9.00	0.01
880.0	179.00	9.10	0.01
890.0	181.00	9.20	0.01
900.0	183.00	9.30	0.01
910.0	185.00	9.40	0.01
920.0	187.00	9.50	0.01
930.0	189.00	9.60	0.01
940.0	191.00	9.70	0.01
950.0	193.00	9.80	0.01
960.0	195.00	9.90	0.01
970.0	197.00	10.00	0.01
980.0	199.00	10.10	0.01
990.0	201.00	10.20	0.01
1000.0	203.00	10.30	0.01

Table 10

AVERAGE PLANT HEIGHT OF CHINESE AND CHINESE LINES WITH
SUBSTITUTED THATCHER, HOPE, AND TIMSTEIN CHROMOSOMES
IN 1953 AND 1954

Chromosome tested	THATCHER		HOPE		TIMSTEIN		THAT- CHER	HOPE	TIMS- TEIN	LINES
	1953	1954	1953	1954	1953	1954				
Chinese	40.9	49.1	40.9	49.7	41.0	48.3	45.0	45.3	44.6	45.0
1	41.2	48.7	42.1	50.2	42.4	50.1	44.9	46.2	46.3	45.8
2	38.6	48.4	41.7	47.2	41.2	47.9	43.5	44.5	44.6	44.2
3	41.8	50.0	40.3	44.7	40.7	48.9	45.9	42.5	44.8	44.4
4	40.5	49.2	41.3	48.4	40.5	48.6	44.8	44.9	44.5	44.7
5	39.3	47.8	40.9	47.0	44.0	49.5	43.5	43.9	46.7	44.7
6	42.4	53.2	40.6	48.5	41.4	47.4	47.8	44.5	44.4	45.6
7	40.2	41.8	39.3	43.1	41.2	48.6	43.5	41.2	44.8	43.2
8	39.0	44.9	39.5	43.8	39.3	45.1	42.0	41.6	42.2	41.9
9	39.5	50.2	39.8	43.4	42.3	47.3	44.9	41.6	44.8	43.7
10	40.4	49.8	41.1	46.3	42.0	44.0	45.1	43.7	45.5	44.8
11	40.8	52.7	40.4	49.9	42.8	51.2	46.7	45.2	47.0	46.3
12	42.4	50.0	41.0	41.9	41.5	46.3	46.2	41.5	43.9	43.8
15	41.2	49.4	39.9	47.4	40.6	47.3	45.3	43.6	44.0	44.3
16	40.1	47.5	41.9	49.7	40.5	49.1	44.0	45.8	44.8	44.9
19	41.5	50.9	41.4	48.5	44.3	50.0	46.2	44.9	47.1	46.1
20	40.8	49.4	40.9	49.7	39.6	47.5	45.1	45.3	43.5	44.6
21	41.0	49.5	42.7	48.4	44.1	49.9	45.2	45.5	47.0	45.9
L.S.D. - 5% level			- 2.24				- 2.03		- 1.95	
1% level			- 2.97				- 2.73		- 2.62	

4. Lodging

Data on lodging in each of the three sets of Chinese substitution lines are summarized in Tables 11, 12, and 13.

The donor varieties have much greater lodging resistance than the recipient parent. If lodging is genetically controlled, some of the substitution lines possessing chromosomes from the more lodging resistant donor varieties should show less susceptibility to lodging than Chinese. Also, some of the substitution lines might have less lodging resistance than Chinese. If the differences among the lines were largely environmental and not genetical, little or no consistency would be expected in line-lodging-values from year to year. Lodging scores for most individual lines were, however, very consistent, as shown by the non-significance of the lines x years interaction (Table 24 of the Appendix). It can be assumed, therefore, that differences among substitution lines were caused by genetic differences affecting this character. A few lines, however, were not consistent. They are Chinese XVI Thatcher, Chinese XIX Thatcher, Chinese II Hope, Chinese XIX Hope, and Chinese IX Timstein. It was mainly because of this inconsistency of lines within sets that caused the triple interaction lines x years x varieties to be significant. The interaction is, however, difficult to interpret.

Assuming that differences in lodging resistance exceeding the 5% level of significance are caused by genetic effects of substituted chromosomes three phenotypic classes may be assumed:

- (a) lodging resistance significantly greater than Chinese,
- (b) lodging resistance the same as or similar to Chinese, and
- (c) lodging resistance significantly less than Chinese.

	Thatcher set of substitu- tion lines.	Hope set of sub- stitution lines.	Timstein set of substitu- tion lines.
Significantly greater than Chinese	I, II, III, IV, V, VI, VII, VIII, IX, XII, XIII, XVI, XIX, XX, XXI.	I, II, III, IV, V, VI, VII, VIII, IX, XII, XVII, XIX, XXI.	I, IV, V, VIII, IX, X, XV, XVIII, XIX.
Similar to Chinese	X, XI, XV, XVIII.	X, XI, XV, XVI, XVIII, XX.	II, III, VI, VII, XI, XVI, XVII, XX, XXI.
Significantly less than Chinese	-----	-----	-----

None of the lines were significantly lower in lodging than Chinese.

In the group of chromosome lines that are not significantly different from Chinese, it is very likely that there are either no effective genes for this character on these chromosomes of both the donor and recipient varieties, or if there are, they have similar effects.

The group of lines that are significantly stronger strawed than Chinese is rather large, and varies with the different donor parents. One of the main reasons for the large number of significant lines is that Chinese is a very weak strawed variety and the donors are very strong strawed. The effects of the chromosomes that give significant results are not all equal. Some of the lines significantly higher than Chinese are significantly higher or lower than other lines showing significant results. Chinese I Thatcher, for example, is significantly more resistant to lodging than Chinese XXI Thatcher, yet both are significantly more resistant to lodging than Chinese. This indicates that some chromo-

somes have major and others minor genetic effects.

The interaction lines x varieties within years (Tables 25 and 26 of the Appendix) was highly significant. This may be interpreted to mean that some of the homologous chromosomes of donor and recipient varieties are significantly different in genetic effects from each other. Chromosome XXI is of this type. Chinese XXI Thatcher and Chinese XXI Hope were resistant and Chinese XXI Timstein was susceptible. Other chromosome lines showing the same type of effect are I, IV, VII, X, XIX, and XX.

Table 14 shows the average lodging scores of Chinese and Chinese lines with substituted Thatcher, Hope, and Timstein chromosomes in 1953 and 1954. L.S.D.'s were computed for (a) lines within sets within years, (b) lines within sets, and (c) lines over sets and years.

If the line effect is due to one gene per chromosome, lines which are non-significantly different from Chinese may be assumed to possess the same allele as the recipient parent. An alternative to this is possible. Since lodging is probably controlled by many genes and since each gene has a very small effect, (even though certain lines are statistically non-significantly different from Chinese) the chromosome from the donor variety may carry a different allele. If the assumption that each chromosome affects lodging through the action of a single gene is correct, and since homologous chromosome lines vary in lodging resistance, we must assume a series of multiple alleles of different strengths affecting lodging. Statistical substantiation for this assumption is present in Tables 25 and 26 of the Appendix.

The alternative to the above situation may be that the effect of any one chromosome is due to more than one gene with or without a series of alleles for each. If the chromosomes effect is dependent on the

number of genes present, with genes on all chromosomes having equal or approximately equal effects, then line differences are rough estimations of number of genes. However, if chromosomes differ in number of genes and a multiple allelic series exists for each gene, a very complex organization of almost impossible genetic determination exists. In any event, it is clear from the data that there are some chromosomes that have what may be termed major genetic effects as well as those having minor genetic effects.

Since none of the lines were significantly lower in lodging resistance than Chinese, it is possible that Chinese possesses most of the genes for low lodging resistance. Also, the donors appear to possess a near maximum of resistance genes. Since many chromosomes affect lodging significantly, 15 in Thatcher, 13 in Hope and 10 in Timstein, it seems that the effects of individual genes are small, although not necessarily equal as previously shown. From these studies, it appears that lodging is a genetically complex character affected by at least 15 genes or groups of genes.

Table 11

LODGING SCORES OF THATCHER, CHINESE, AND CHINESE LINES
WITH SUBSTITUTED THATCHER CHROMOSOMES

Chromosome tested	1952 [*]	1953 [*]	1954 [*]	Average
Thatcher	10.0	9.6	9.8	9.8
Chinese	4.5	4.0	3.5	4.0
1	9.0	8.2	8.5	8.6
2	8.0	7.0	7.5	7.5
3	7.0	6.3	5.8	6.4
4	6.0	5.5	6.0	5.8
5	7.0	7.7	8.5	7.7
6	7.0	6.0	6.5	6.5
7	7.0	6.3	6.8	6.7
8	8.5	8.0	7.8	8.1
9	8.0	7.8	6.5	7.4
10	5.5	4.4	2.5	4.1
11	4.5	4.2	3.8	4.2
12	6.0	6.1	5.5	5.9
13	7.0	6.2		6.6
15	5.5	3.9	4.0	4.5
16	6.0	6.6	4.0	5.5
18		4.6		4.6
19	6.0	4.6	6.5	5.7
20	6.0	6.0	6.5	6.2
21	6.5	6.5	7.0	6.7
L.S.D. - 5% level	1.19	1.19	3.58	1.05
1% level	1.58	1.58	4.86	1.41

* 1952, 1953 - 4 replicates

* 1954 - 2 replicates

TABLE I. The average values of the parameters of the distribution of the number of successes in a series of trials.

Series	N	p	q	h
1	10	0.1	0.9	10
2	10	0.2	0.8	10
3	10	0.3	0.7	10
4	10	0.4	0.6	10
5	10	0.5	0.5	10
6	10	0.6	0.4	10
7	10	0.7	0.3	10
8	10	0.8	0.2	10
9	10	0.9	0.1	10
10	10	1.0	0.0	10
11	20	0.1	0.9	20
12	20	0.2	0.8	20
13	20	0.3	0.7	20
14	20	0.4	0.6	20
15	20	0.5	0.5	20
16	20	0.6	0.4	20
17	20	0.7	0.3	20
18	20	0.8	0.2	20
19	20	0.9	0.1	20
20	20	1.0	0.0	20
21	30	0.1	0.9	30
22	30	0.2	0.8	30
23	30	0.3	0.7	30
24	30	0.4	0.6	30
25	30	0.5	0.5	30
26	30	0.6	0.4	30
27	30	0.7	0.3	30
28	30	0.8	0.2	30
29	30	0.9	0.1	30
30	30	1.0	0.0	30
31	40	0.1	0.9	40
32	40	0.2	0.8	40
33	40	0.3	0.7	40
34	40	0.4	0.6	40
35	40	0.5	0.5	40
36	40	0.6	0.4	40
37	40	0.7	0.3	40
38	40	0.8	0.2	40
39	40	0.9	0.1	40
40	40	1.0	0.0	40
41	50	0.1	0.9	50
42	50	0.2	0.8	50
43	50	0.3	0.7	50
44	50	0.4	0.6	50
45	50	0.5	0.5	50
46	50	0.6	0.4	50
47	50	0.7	0.3	50
48	50	0.8	0.2	50
49	50	0.9	0.1	50
50	50	1.0	0.0	50

where N is the number of trials, p is the probability of success, q is the probability of failure, h is the number of successes.

Table 12

LODGING SCORES OF HOPE, CHINESE, AND CHINESE LINES
WITH SUBSTITUTED HOPE CHROMOSOMES

Chromosome tested	1953	1954	Average
Hope	9.1	9.6	9.4
Chinese	4.4	3.5	4.0
1	6.8	6.0	6.4
2	7.1	8.3	7.7
3	7.5	7.6	7.6
4	6.6	5.3	6.0
5	7.0	7.1	7.1
6	6.2	6.8	6.5
7	7.1	8.3	7.7
8	7.4	6.4	6.9
9	7.3	8.5	7.9
10	5.5	5.3	5.4
11	3.4	2.6	3.0
12	7.1	7.5	7.3
15	4.4	4.8	4.6
16	5.0	4.9	5.0
17	5.5	6.9	6.2
18		5.0	5.0
19	7.9	4.6	6.3
20	4.7	2.6	3.7
21	6.6	8.3	7.5
L.S.D. - 5% level	2.34	3.58	1.86
1% level	3.12	4.76	2.55

Table 13

LODGING SCORES OF TIMSTEIN, CHINESE, AND CHINESE LINES
WITH SUBSTITUTED TIMSTEIN CHROMOSOMES

Chromosome tested	1953	1954	Average
Timstein	9.3	10.0	9.7
Chinese	5.2	3.5	4.4
1	7.1	6.9	7.0
2	5.6	6.8	6.2
3	5.6	5.1	5.4
4	6.6	6.4	6.5
5	7.4	8.4	7.9
6	5.9	6.1	6.0
7	5.7	5.9	5.8
8	8.6	7.6	8.1
9	4.7	8.5	8.0
10	8.4	7.3	7.9
11	5.4	5.5	5.5
12	5.5	7.0	6.3
15	5.7	7.0	6.4
16	5.9	4.9	5.4
17	6.1	6.3	6.2
18	5.9	6.9	6.4
19	8.3	7.5	7.9
20	4.7	3.5	4.1
21	5.2	4.0	4.6
L.S.D. - 5% level	1.32	2.94	1.88
1% level	1.76	3.91	2.56

Table 14

AVERAGE LODGING SCORES OF CHINESE AND CHINESE LINES
WITH SUBSTITUTED THATCHER, HOPE, AND TIMSTEIN CHRO-
MOSOMES IN 1953 AND 1954

Chromosome tested	THATCHER		HOPE		TIMSTEIN		THAT- CHER	HOPE	TIMS- TEIN	LINES
	1953	1954	1953	1954	1953	1954				
Chinese	3.7	3.5	3.9	3.0	4.6	3.5	3.6	3.5	4.1	3.7
1	8.1	8.5	7.4	6.0	6.9	6.3	8.3	6.7	6.6	7.2
2	6.6	7.5	5.9	8.3	5.7	6.5	7.1	7.1	6.1	6.7
3	5.6	5.8	7.3	7.3	4.8	4.8	5.7	7.3	4.8	5.9
4	4.6	3.0	7.0	5.5	6.1	5.8	3.8	6.3	5.9	5.3
5	8.0	8.5	6.3	7.8	8.5	9.0	8.3	7.0	8.8	8.0
6	6.1	6.5	5.9	6.5	5.5	6.3	6.3	6.2	5.9	6.1
7	6.4	6.8	8.3	8.3	5.3	5.8	6.6	8.3	5.5	6.8
8	8.1	7.8	7.0	6.8	8.4	7.3	7.9	6.9	7.8	7.5
9	8.6	6.5	7.2	8.5	4.7	8.3	7.6	7.9	6.5	7.3
10	3.6	2.5	4.6	5.0	8.3	7.5	3.1	4.8	7.9	5.3
11	4.1	3.8	3.3	2.3	4.8	5.0	3.9	2.8	4.9	3.9
12	6.4	5.5	7.0	7.0	5.4	7.0	6.0	7.0	6.2	6.4
15	3.7	4.0	3.5	5.0	5.2	6.8	3.9	4.3	6.0	4.7
16	7.4	4.0	4.1	4.8	4.5	5.3	5.7	4.4	4.9	5.0
19	3.7	6.5	7.6	4.3	8.2	7.0	5.1	5.9	7.6	6.2
20	6.5	6.5	4.2	2.3	3.6	3.0	6.5	3.2	3.3	4.3
21	6.2	7.0	7.0	8.3	5.3	3.5	6.6	7.6	4.4	6.2
L.S.D. - 5% level	--	--	1.63	--	--	--	--	1.99	--	2.02
1% level	--	--	2.15	--	--	--	--	2.67	--	2.72

* Two replicates from each set of substitution lines were used to compute above values.

5. Protein Content

Data on protein content of Thatcher, Chinese, and Chinese lines with substituted Thatcher chromosomes are summarized in Table 15.

Although protein content is greatly influenced by environmental conditions, most of the chromosome lines gave consistent results from year to year.

Lines V, VII, IX, XV, and XVI were significantly higher in protein content, at the 5% level, than Chinese. These lines also transgressed the protein content of the donor variety. None of the 19 lines tested were significantly lower in protein content than Chinese.

Inheritance of protein content in this set of substitution lines appears to be controlled by genes on at least five chromosomes, V, VII, IX, XV, and XVI. Whether the chromosomal effect is due to one or more genes cannot be determined at present. However, the effects of genes on different chromosomes, whose lines are significantly different from Chinese, appear to be similar (Table 15). In cases where lines are not significantly different from Chinese two assumptions may be made. Homologous chromosomes of both donor and recipient varieties carry similar or nearly similar genes or they do not carry any genes affecting this character.

Table 15

PROTEIN CONTENT OF THATCHER, CHINESE AND CHINESE LINES
WITH SUBSTITUTED THATCHER CHROMOSOMES

Chromosome tested	1950	1951	1952	1953	Average
1	16.5	12.4	14.2	13.4	14.1
2	16.6	13.2	14.1	14.8	14.7
3	16.6	13.0	13.7	14.4	14.4
4	16.3	13.2	13.7	15.0	14.6
5	17.2	14.6	13.7	15.7	15.3
6	15.9	13.2	13.6	15.0	14.4
7	16.7	14.2	14.4	15.4	15.2
8	16.3	12.9	13.8	14.2	14.3
9	16.4	14.8	14.1	14.9	15.1
10	15.4	13.6	14.1	15.0	14.5
11	16.5	13.2	13.7	15.4	14.7
12	15.9	12.8	13.3	14.3	14.1
13			13.8	14.4	14.1
15	16.1	14.1	14.1	15.2	14.9
16	17.3	14.3	14.7	14.9	15.3
18	15.7	14.0	13.8	14.5	14.5
19	16.1	12.7	13.3	14.4	14.1
20	16.5	13.4	13.9	14.8	14.7
21	16.1	13.9	14.2	15.0	14.8
Thatcher	16.6	13.7	14.1	15.2	14.9
Chinese	15.7	12.8	13.4	14.7	14.2
L.S.D. -- 5% level					0.60
1% level					0.80

6. Spike Density

Data on spike density for each of the three sets of Chinese substitution lines are summarized in Tables 16, 17, and 18.

No major gene differences for spike density have been found by conventional methods between varieties within the vulgare species possessing lax spikes. Since the donor and recipient varieties are all lax spiked no major gene differences should be expected in the substitution lines.

Varieties within the vulgare species probably differ only in number of minor genes distributed on the various chromosomes.

The donor varieties were in all cases less dense than the recipient variety. None of the lines were as lax as the donor varieties. Most of the lines had densities equal to or lower than Chinese. Spike densities of individual lines were consistent from year to year as was shown by the non significance of the lines x years interaction (Table 34 of the Appendix). Chinese XVI Thatcher showed the most marked deviation; in 1952, it was highly significant, and in 1953 and 1954 it was equal to Chinese in spike density.

As expected, results indicate no major gene differences; only minor genes modifying the degree of density were presumably associated with specific chromosomes.

If differences in spike density exceeding the 5% level are those caused by genetic effects of substituted chromosomes, then the following three phenotypic classes may be assumed: (1) those significantly more dense than Chinese, (11) those the same as or similar to Chinese, and (111) those significantly less dense than Chinese.

	Thatcher	Hope	Timstein
Significantly more dense	IV	II	XII
Same as or similar to Chinese	II, V, VI, XI, XII, XIII, XV, XVI, XVIII, XX	I, III, IV, V, VI, VII, IX, XI, XII, XV, XVI, XVII, XVIII, XIX, XXI	I, II, IV, IX, XV, XVII, XVIII
Significantly less dense	I, III, VI, VIII, IX, X, XIX, XXI	VIII, X, XX	III, V, VI, VII, VIII, X, XI, XVI, XIX, XX, XXI

Three lines, Chinese IV Thatcher, Chinese II Hope, and Chinese XII Timstein transgressed the density of Chinese by being significantly more dense. Thatcher chromosome IV seems to carry genes decreasing spike length, the number of spikelets remaining the same as in Chinese. In Hope chromosome II and Timstein chromosome XII both spike length and spikelet number are disproportionally decreased.

In the group of chromosomes that are not significantly different from Chinese, it is quite likely that either there are no effective genes for this character on these chromosomes of both the donor and recipient varieties, or if there are, they have similar effects. Substitution lines XV and XVIII of all 3 donor varieties were similar to the recipient parent in spike density.

Thatcher chromosomes I, III, VI, VIII, IX, X, XIX, and XXI; Hope chromosomes VIII, X, and XX, and Timstein chromosomes III, V, VI, VII, VIII, X, XI, XVI, XIX, XX, and XXI produce lines with significantly less spike density than Chinese. Substitution lines Chinese X Thatcher, Chinese VIII of Hope, Chinese XX Hope and Chinese XX Timstein had spike

density values 0.5 to 0.7 centimeters lower than Chinese. The other lines did not show as striking results. The fact that different chromosomes within each set of substitution lines gave significantly more dense types, similar types, and significantly less dense types, than Chinese shows that the effects of the chromosomes are not equal. This seems to signify that some chromosomes have major and others minor genetic effects. Also, there probably are chromosomes with no effect on this character. Generally, results seem to show that both strong and weak minor genes are present on different chromosomes within a variety. The degree to which any variety will be more or less dense than any other will depend on the number of accumulated strong and weak minor genes.

Since we are testing whole chromosomes it is impossible on this basis to predict whether the chromosome behavior with respect to spike density is due to one or more genes. That homologous chromosomes from different varieties are, in some cases, significantly different in genetic effects from each other is substantiated by a highly significant lines x variety interaction (Tables 35 and 36 of the Appendix). This significant interaction may support either of three alternatives: (a) individual chromosomes affect spike density due to one gene per chromosome with a series of 2 or more alleles, or (b) each chromosome may possess more than one gene and each of these may possess a series of 2 or more alleles, and (c) a mixture of both.

Average spike densities of Chinese and Chinese lines with substituted Thatcher, Hope, and Timstein chromosomes in 1953 and 1954 are summarized in Table 19 together with L.S.D.'s for (a) lines within years within sets, (b) lines within sets, and (c) lines over years and sets.

Chromosomes with major and minor effects modify spike density. Some chromosomes as IV of Thatcher, II of Hope, and XII of Timstein all

increase density significantly and to the same degree. Eight chromosomes of Thatcher, three of Hope, and eleven of Timstein decrease density significantly; the degree of spike density varies with different chromosomes.

Table 16

SPIKE DENSITIES OF THATCHER, CHINESE, AND CHINESE LINES
WITH SUBSTITUTED THATCHER CHROMOSOMES

Chromosome tested	1952	1953	1954	Average
Thatcher	2.36	1.96	2.31	2.21
Chinese	3.26	2.88	3.47	3.20
1	2.90	2.70	3.13	2.91
2	3.18	2.71	3.27	3.05
3	2.99	2.34	2.98	2.77
4	3.73	3.07	3.61	3.47
5	3.17	2.69	3.10	2.99
6	2.98	2.38	3.04	2.80
7	3.36	2.63	3.13	3.04
8	3.39	2.30	2.81	2.83
9	2.90	2.52	2.94	2.79
10	2.94	2.38	2.74	2.69
11	3.12	2.78	3.33	3.08
12	3.24	2.50	3.09	2.94
13		2.99	3.22	3.11
15	3.46	2.66	3.41	3.18
16	4.23	2.80	3.44	3.49
18		3.14	3.36	3.25
19	3.10	2.60	3.02	2.91
20	3.35	2.53	3.28	3.05
21	2.86	2.54	2.93	2.78
L.S.D. - 5% level	0.149	0.088	0.236	0.27
1% level	0.198	0.117	0.320	0.37

Table 17

SPIKE DENSITIES OF HOPE, CHINESE, AND CHINESE LINES
WITH SUBSTITUTED HOPE CHROMOSOMES

Chromosome tested	1953	1954	Average
Hope	1.96	2.33	2.15
Chinese	2.93	3.33	3.13
1	2.95	3.28	3.12
2	3.28	3.75	3.52
3	2.79	3.28	3.04
4	2.86	3.33	3.10
5	2.73	3.23	2.98
6	2.63	3.13	2.88
7	2.71	3.27	2.99
8	2.41	2.88	2.65
9	3.08	3.64	3.36
10	2.22	2.74	2.48
11	2.89	3.17	3.03
12	3.21	3.56	3.39
15	2.84	3.23	3.04
16	3.00	3.48	3.24
17	2.65	3.18	2.92
18		3.40	3.40
19	2.86	3.19	3.03
20	2.33	3.01	2.67
21	2.72	3.23	2.98
L.S.D. - 5% level	0.100	0.184	0.33
1% level	0.133	0.245	0.46

Year	Age	Sex	Weight
1900	10	M	100
1901	11	M	110
1902	12	M	120
1903	13	M	130
1904	14	M	140
1905	15	M	150
1906	16	M	160
1907	17	M	170
1908	18	M	180
1909	19	M	190
1910	20	M	200
1911	21	M	210
1912	22	M	220
1913	23	M	230
1914	24	M	240
1915	25	M	250
1916	26	M	260
1917	27	M	270
1918	28	M	280
1919	29	M	290
1920	30	M	300
1921	31	M	310
1922	32	M	320
1923	33	M	330
1924	34	M	340
1925	35	M	350
1926	36	M	360
1927	37	M	370
1928	38	M	380
1929	39	M	390
1930	40	M	400
1931	41	M	410
1932	42	M	420
1933	43	M	430
1934	44	M	440
1935	45	M	450
1936	46	M	460
1937	47	M	470
1938	48	M	480
1939	49	M	490
1940	50	M	500
1941	51	M	510
1942	52	M	520
1943	53	M	530
1944	54	M	540
1945	55	M	550
1946	56	M	560
1947	57	M	570
1948	58	M	580
1949	59	M	590
1950	60	M	600
1951	61	M	610
1952	62	M	620
1953	63	M	630
1954	64	M	640
1955	65	M	650
1956	66	M	660
1957	67	M	670
1958	68	M	680
1959	69	M	690
1960	70	M	700
1961	71	M	710
1962	72	M	720
1963	73	M	730
1964	74	M	740
1965	75	M	750
1966	76	M	760
1967	77	M	770
1968	78	M	780
1969	79	M	790
1970	80	M	800
1971	81	M	810
1972	82	M	820
1973	83	M	830
1974	84	M	840
1975	85	M	850
1976	86	M	860
1977	87	M	870
1978	88	M	880
1979	89	M	890
1980	90	M	900
1981	91	M	910
1982	92	M	920
1983	93	M	930
1984	94	M	940
1985	95	M	950
1986	96	M	960
1987	97	M	970
1988	98	M	980
1989	99	M	990
1990	100	M	1000

Table 18

SPIKE DENSITIES OF TIMSTEIN, CHINESE, AND CHINESE LINES
WITH SUBSTITUTED TIMSTEIN CHROMOSOMES

Chromosome tested	1953	1954	Average
Timstein	1.76	2.05	1.91
Chinese	2.91	3.44	3.18
1	2.82	3.30	3.06
2	2.96	3.63	3.30
3	2.54	3.04	2.79
4	2.97	3.63	3.30
5	2.66	3.18	2.92
6	2.64	3.22	2.93
7	2.69	3.28	2.99
8	2.63	3.22	2.93
9	2.84	3.65	3.25
10	2.74	3.09	2.92
11	2.65	3.06	2.86
12	3.18	3.68	3.43
15	3.07	3.37	3.22
16	2.69	3.30	3.00
17	2.75	3.39	3.07
18	2.93	3.51	3.22
19	2.70	3.15	2.93
20	2.19	2.76	2.48
21	2.72	3.24	2.98
L.S.D. - 5% level	0.092	0.130	0.18
1% level	0.122	0.173	0.25

Table 19

AVERAGE SPIKE DENSITIES OF CHINESE AND CHINESE LINES
WITH SUBSTITUTED THATCHER, HOPE, AND TIMSTEIN CHROMO-
SOMES IN 1953 AND 1954

Chromosome tested	THATCHER		HOPE		TIMSTEIN		THAT- CHER	HOPE	TIMS- TEIN	LINES	
	1953	1954	1953	1954	1953	1954					
Chinese	2.91	3.47	2.98	3.43	2.86	3.49	3.19	3.20	3.17	38.25	
1	2.73	3.13	2.96	3.25	2.89	3.29	2.93	3.10	3.09	36.46	
2	2.75	3.27	3.24	3.73	2.92	3.64	3.00	3.48	3.28	39.07	
3	2.39	2.98	2.82	3.28	2.61	3.04	2.68	3.05	2.82	34.20	
4	3.08	3.61	2.85	3.29	3.01	3.64	3.34	3.07	3.32	38.94	
5	2.76	3.10	2.76	3.12	2.70	3.23	2.93	2.94	2.96	35.31	
6	2.40	3.04	2.64	3.06	2.68	3.21	2.72	2.84	2.94	34.01	
7	2.65	3.13	2.71	3.34	2.67	3.38	2.89	3.02	3.02	35.73	
8	2.32	2.81	2.45	2.93	2.64	3.16	2.56	2.69	2.89	32.58	
9	2.52	2.94	3.14	3.58	2.85	3.72	2.73	3.36	3.28	37.46	
10	2.31	2.74	2.24	2.75	2.78	3.07	2.52	2.49	2.92	31.73	
11	2.80	3.33	2.90	3.19	2.67	3.11	3.06	3.04	2.89	35.96	
12	2.50	3.09	3.20	3.57	3.18	3.81	2.80	3.38	3.49	38.68	
15	2.69	3.41	2.86	3.23	3.14	3.43	3.05	3.05	3.28	37.50	
16	2.82	3.44	2.99	3.43	2.72	3.27	3.13	3.21	2.99	37.33	
19	2.61	3.02	2.90	3.16	2.68	3.14	2.82	3.03	2.91	34.99	
20	2.55	3.28	2.30	2.96	2.25	2.75	2.91	2.63	2.50	32.15	
21	2.59	2.93	2.78	3.23	2.77	3.21	2.76	3.00	2.99	34.99	
<hr/>											
L.S.D. - 5% level	--		0.20				--		0.20	--	0.38
1% level	--		0.26				--		0.26	--	0.52

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No.	Name			Sex		Age		Height		Remarks
	First	Middle	Last	Male	Female	Years	Months	Feet	Inches	
1	John	William	Smith	Male		25	0	5	8	
2	Mary	Ann	Smith		Female	22	6	5	4	1
3	James	Robert	Smith	Male		20	0	5	7	2
4	Elizabeth	Ann	Smith		Female	18	0	5	6	3
5	Thomas	John	Smith	Male		15	0	5	5	4
6	William	Robert	Smith	Male		12	0	5	4	5
7	John	William	Smith	Male		10	0	5	3	6
8	Mary	Ann	Smith		Female	8	0	5	2	7
9	James	Robert	Smith	Male		6	0	5	1	8
10	Elizabeth	Ann	Smith		Female	4	0	5	0	9
11	Thomas	John	Smith	Male		3	0	5	0	10
12	William	Robert	Smith	Male		2	0	5	0	11
13	John	William	Smith	Male		1	0	5	0	12
14	Mary	Ann	Smith		Female	0	0	5	0	13
15	James	Robert	Smith	Male		0	0	5	0	14
16	Elizabeth	Ann	Smith		Female	0	0	5	0	15
17	Thomas	John	Smith	Male		0	0	5	0	16
18	William	Robert	Smith	Male		0	0	5	0	17
19	John	William	Smith	Male		0	0	5	0	18
20	Mary	Ann	Smith		Female	0	0	5	0	19
21	James	Robert	Smith	Male		0	0	5	0	20
22	Elizabeth	Ann	Smith		Female	0	0	5	0	21
23	Thomas	John	Smith	Male		0	0	5	0	22
24	William	Robert	Smith	Male		0	0	5	0	23
25	John	William	Smith	Male		0	0	5	0	24
26	Mary	Ann	Smith		Female	0	0	5	0	25
27	James	Robert	Smith	Male		0	0	5	0	26
28	Elizabeth	Ann	Smith		Female	0	0	5	0	27
29	Thomas	John	Smith	Male		0	0	5	0	28
30	William	Robert	Smith	Male		0	0	5	0	29
31	John	William	Smith	Male		0	0	5	0	30
32	Mary	Ann	Smith		Female	0	0	5	0	31
33	James	Robert	Smith	Male		0	0	5	0	32
34	Elizabeth	Ann	Smith		Female	0	0	5	0	33
35	Thomas	John	Smith	Male		0	0	5	0	34
36	William	Robert	Smith	Male		0	0	5	0	35
37	John	William	Smith	Male		0	0	5	0	36
38	Mary	Ann	Smith		Female	0	0	5	0	37
39	James	Robert	Smith	Male		0	0	5	0	38
40	Elizabeth	Ann	Smith		Female	0	0	5	0	39
41	Thomas	John	Smith	Male		0	0	5	0	40
42	William	Robert	Smith	Male		0	0	5	0	41
43	John	William	Smith	Male		0	0	5	0	42
44	Mary	Ann	Smith		Female	0	0	5	0	43
45	James	Robert	Smith	Male		0	0	5	0	44
46	Elizabeth	Ann	Smith		Female	0	0	5	0	45
47	Thomas	John	Smith	Male		0	0	5	0	46
48	William	Robert	Smith	Male		0	0	5	0	47
49	John	William	Smith	Male		0	0	5	0	48
50	Mary	Ann	Smith		Female	0	0	5	0	49
51	James	Robert	Smith	Male		0	0	5	0	50
52	Elizabeth	Ann	Smith		Female	0	0	5	0	51
53	Thomas	John	Smith	Male		0	0	5	0	52
54	William	Robert	Smith	Male		0	0	5	0	53
55	John	William	Smith	Male		0	0	5	0	54
56	Mary	Ann	Smith		Female	0	0	5	0	55
57	James	Robert	Smith	Male		0	0	5	0	56
58	Elizabeth	Ann	Smith		Female	0	0	5	0	57
59	Thomas	John	Smith	Male		0	0	5	0	58
60	William	Robert	Smith	Male		0	0	5	0	59
61	John	William	Smith	Male		0	0	5	0	60
62	Mary	Ann	Smith		Female	0	0	5	0	61
63	James	Robert	Smith	Male		0	0	5	0	62
64	Elizabeth	Ann	Smith		Female	0	0	5	0	63
65	Thomas	John	Smith	Male		0	0	5	0	64
66	William	Robert	Smith	Male		0	0	5	0	65
67	John	William	Smith	Male		0	0	5	0	66
68	Mary	Ann	Smith		Female	0	0	5	0	67
69	James	Robert	Smith	Male		0	0	5	0	68
70	Elizabeth	Ann	Smith		Female	0	0	5	0	69
71	Thomas	John	Smith	Male		0	0	5	0	70
72	William	Robert	Smith	Male		0	0	5	0	71
73	John	William	Smith	Male		0	0	5	0	72
74	Mary	Ann	Smith		Female	0	0	5	0	73
75	James	Robert	Smith	Male		0	0	5	0	74
76	Elizabeth	Ann	Smith		Female	0	0	5	0	75
77	Thomas	John	Smith	Male		0	0	5	0	76
78	William	Robert	Smith	Male		0	0	5	0	77
79	John	William	Smith	Male		0	0	5	0	78
80	Mary	Ann	Smith		Female	0	0	5	0	79
81	James	Robert	Smith	Male		0	0	5	0	80
82	Elizabeth	Ann	Smith		Female	0	0	5	0	81
83	Thomas	John	Smith	Male		0	0	5	0	82
84	William	Robert	Smith	Male		0	0	5	0	83
85	John	William	Smith	Male		0	0	5	0	84
86	Mary	Ann	Smith		Female	0	0	5	0	85
87	James	Robert	Smith	Male		0	0	5	0	86
88	Elizabeth	Ann	Smith		Female	0	0	5	0	87
89	Thomas	John	Smith	Male		0	0	5	0	88
90	William	Robert	Smith	Male		0	0	5	0	89
91	John	William	Smith	Male		0	0	5	0	90
92	Mary	Ann	Smith		Female	0	0	5	0	91
93	James	Robert	Smith	Male		0	0	5	0	92
94	Elizabeth	Ann	Smith		Female	0	0	5	0	93
95	Thomas	John	Smith	Male		0	0	5	0	94
96	William	Robert	Smith	Male		0	0	5	0	95
97	John	William	Smith	Male		0	0	5	0	96
98	Mary	Ann	Smith		Female	0	0	5	0	97
99	James	Robert	Smith	Male		0	0	5	0	98
100	Elizabeth	Ann	Smith		Female	0	0	5	0	99

7. Thousand-Kernel Weight

Data on thousand-kernel weight in each of the three sets of Chinese substitution lines are summarized in Tables 20, 21, and 22.

The donor parents, Thatcher, Hope, and Timstein, were each significantly heavier (5% level) in thousand-kernel weight than Chinese. Chinese XVI Thatcher was the only line that was significantly lower in thousand-kernel weight than the recipient variety.

The following lines were significantly heavier (5% level) in thousand-kernel weight than Chinese: Chinese I Thatcher, Chinese V Thatcher, Chinese I Hope, Chinese IV Hope, Chinese VI Hope, Chinese I Timstein, Chinese V Timstein, Chinese VI Timstein, Chinese X Timstein, and Chinese XIX Timstein.

It may be assumed that at least seven chromosomes, I, IV, V, VI, X, XVI, and XIX, carry genes affecting kernel weight. Chromosome I had the greatest effects involving all three donor varieties. In every case the size of kernel was significantly increased by the substitution of this chromosome. Chinese XVI Thatcher line showed a significant reduction in kernel size.

Table 20

THOUSAND-KERNEL WEIGHTS OF THATCHER, CHINESE, AND
CHINESE LINES WITH SUBSTITUTED THATCHER CHROMOSOMES

Chromosome tested	1953	1953	1954	Average
Thatcher	30.9	32.4	30.7	31.3
Chinese	27.0	22.6	18.6	22.7
1	30.3	32.1	26.4	29.6
2	27.6	25.5	19.8	24.3
3	27.3	24.1	21.7	24.4
4	26.9	24.3	16.8	22.7
5	28.7	24.5	23.5	25.6
6	27.7	21.8	23.7	24.4
7	27.3	22.4	20.5	23.4
8	28.5	25.9	17.9	24.1
9	27.9	23.3	18.2	23.1
10	24.2	21.8	17.4	21.1
11	28.7	22.1	18.2	23.0
12	27.5	24.1	17.7	23.1
13		24.0	21.4	22.7
15	24.8	21.6	19.6	22.0
16	19.9	21.0	17.0	19.3
18	22.6	22.2	16.1	20.3
19	25.3	24.6	19.9	23.3
20	26.7	22.9	17.2	22.3
21	26.2	25.8	19.5	23.8
L.S.D. - 5% level				3.00
1% level				4.00

Table 21

THOUSAND-KERNEL WEIGHTS OF HOPE, CHINESE, AND CHINESE
LINES WITH SUBSTITUTED HOPE CHROMOSOMES

Chromosome tested	1952	1953	1954	Average
Hope	34.2	38.7	36.7	36.5
Chinese	26.7	22.2	18.8	22.6
1	28.0	29.4	23.6	27.0
2	25.0	26.1	23.2	24.8
3	27.1	24.0	26.3	25.8
4	28.1	28.5	21.7	26.1
5	27.7	25.5	21.4	24.9
6	29.6	27.0	23.8	26.8
7	25.7	23.1	23.7	24.2
8	23.7	22.8	19.6	22.0
9	27.5	23.7	21.9	24.0
10	24.6	22.8	21.9	23.1
11	23.7	21.9	22.3	22.6
12	27.4	25.8	21.9	25.0
15	26.3	22.5	20.3	23.0
16	24.7	24.3	19.0	22.7
17	28.2	23.5	20.4	24.0
18	20.3	21.9	19.4	20.5
19	25.7	28.2	16.9	23.6
20	27.0	19.8	17.5	21.4
21	26.9	24.3	21.1	24.1
L.S.D. - 5% level				3.3
1% level				4.4

TABLE 1. - SUMMARY OF DATA FOR THE 1950-1951 SEASON

STATION	1950	1951	1952	1953
1.01	1.01	1.01	1.01	1.01
1.02	1.02	1.02	1.02	1.02
1.03	1.03	1.03	1.03	1.03
1.04	1.04	1.04	1.04	1.04
1.05	1.05	1.05	1.05	1.05
1.06	1.06	1.06	1.06	1.06
1.07	1.07	1.07	1.07	1.07
1.08	1.08	1.08	1.08	1.08
1.09	1.09	1.09	1.09	1.09
1.10	1.10	1.10	1.10	1.10
1.11	1.11	1.11	1.11	1.11
1.12	1.12	1.12	1.12	1.12
1.13	1.13	1.13	1.13	1.13
1.14	1.14	1.14	1.14	1.14
1.15	1.15	1.15	1.15	1.15
1.16	1.16	1.16	1.16	1.16
1.17	1.17	1.17	1.17	1.17
1.18	1.18	1.18	1.18	1.18
1.19	1.19	1.19	1.19	1.19
1.20	1.20	1.20	1.20	1.20
1.21	1.21	1.21	1.21	1.21
1.22	1.22	1.22	1.22	1.22
1.23	1.23	1.23	1.23	1.23
1.24	1.24	1.24	1.24	1.24
1.25	1.25	1.25	1.25	1.25
1.26	1.26	1.26	1.26	1.26
1.27	1.27	1.27	1.27	1.27
1.28	1.28	1.28	1.28	1.28
1.29	1.29	1.29	1.29	1.29
1.30	1.30	1.30	1.30	1.30
1.31	1.31	1.31	1.31	1.31
1.32	1.32	1.32	1.32	1.32
1.33	1.33	1.33	1.33	1.33
1.34	1.34	1.34	1.34	1.34
1.35	1.35	1.35	1.35	1.35
1.36	1.36	1.36	1.36	1.36
1.37	1.37	1.37	1.37	1.37
1.38	1.38	1.38	1.38	1.38
1.39	1.39	1.39	1.39	1.39
1.40	1.40	1.40	1.40	1.40
1.41	1.41	1.41	1.41	1.41
1.42	1.42	1.42	1.42	1.42
1.43	1.43	1.43	1.43	1.43
1.44	1.44	1.44	1.44	1.44
1.45	1.45	1.45	1.45	1.45
1.46	1.46	1.46	1.46	1.46
1.47	1.47	1.47	1.47	1.47
1.48	1.48	1.48	1.48	1.48
1.49	1.49	1.49	1.49	1.49
1.50	1.50	1.50	1.50	1.50
1.51	1.51	1.51	1.51	1.51
1.52	1.52	1.52	1.52	1.52
1.53	1.53	1.53	1.53	1.53
1.54	1.54	1.54	1.54	1.54
1.55	1.55	1.55	1.55	1.55
1.56	1.56	1.56	1.56	1.56
1.57	1.57	1.57	1.57	1.57
1.58	1.58	1.58	1.58	1.58
1.59	1.59	1.59	1.59	1.59
1.60	1.60	1.60	1.60	1.60
1.61	1.61	1.61	1.61	1.61
1.62	1.62	1.62	1.62	1.62
1.63	1.63	1.63	1.63	1.63
1.64	1.64	1.64	1.64	1.64
1.65	1.65	1.65	1.65	1.65
1.66	1.66	1.66	1.66	1.66
1.67	1.67	1.67	1.67	1.67
1.68	1.68	1.68	1.68	1.68
1.69	1.69	1.69	1.69	1.69
1.70	1.70	1.70	1.70	1.70
1.71	1.71	1.71	1.71	1.71
1.72	1.72	1.72	1.72	1.72
1.73	1.73	1.73	1.73	1.73
1.74	1.74	1.74	1.74	1.74
1.75	1.75	1.75	1.75	1.75
1.76	1.76	1.76	1.76	1.76
1.77	1.77	1.77	1.77	1.77
1.78	1.78	1.78	1.78	1.78
1.79	1.79	1.79	1.79	1.79
1.80	1.80	1.80	1.80	1.80
1.81	1.81	1.81	1.81	1.81
1.82	1.82	1.82	1.82	1.82
1.83	1.83	1.83	1.83	1.83
1.84	1.84	1.84	1.84	1.84
1.85	1.85	1.85	1.85	1.85
1.86	1.86	1.86	1.86	1.86
1.87	1.87	1.87	1.87	1.87
1.88	1.88	1.88	1.88	1.88
1.89	1.89	1.89	1.89	1.89
1.90	1.90	1.90	1.90	1.90
1.91	1.91	1.91	1.91	1.91
1.92	1.92	1.92	1.92	1.92
1.93	1.93	1.93	1.93	1.93
1.94	1.94	1.94	1.94	1.94
1.95	1.95	1.95	1.95	1.95
1.96	1.96	1.96	1.96	1.96
1.97	1.97	1.97	1.97	1.97
1.98	1.98	1.98	1.98	1.98
1.99	1.99	1.99	1.99	1.99
2.00	2.00	2.00	2.00	2.00

TABLE 1. - SUMMARY OF DATA FOR THE 1950-1951 SEASON

TABLE 2.

Table 22

THOUSAND-KERNEL WEIGHTS OF TIMSTEIN, CHINESE, AND
CHINESE LINES WITH SUBSTITUTED TIMSTEIN CHROMOSOMES

Chromosome tested	1952	1953	1954	Average
Timstein	37.6	31.8	37.4	35.6
Chinese	27.2	22.6	18.6	22.8
1	29.4	29.1	20.8	26.4
2	28.8	23.5	20.7	24.3
3	28.5	22.8	20.0	23.8
4	28.3	25.5	19.4	24.4
5	30.4	25.6	23.6	26.5
6	30.4	24.3	22.6	25.8
7	24.0	21.6	21.4	22.3
8	26.4	26.4	19.8	24.2
9		22.8	20.0	21.6
10	27.4	26.4	21.9	25.2
11	28.4	23.7	19.7	23.9
12	27.6	21.6	20.1	23.1
15	25.3	22.5	16.6	21.5
16	25.5	24.3	20.1	23.3
17	25.6	22.2	20.9	22.9
18	25.9	21.9	20.6	22.8
19	28.3	26.1	22.5	25.6
20	28.4	19.8	18.2	22.1
21	26.9	25.5	20.4	24.3

L.S.D. - 5% level

2.4

1% level

3.2

Year	Jan	Feb	Mar	Total
1900	100	100	100	300
1901	100	100	100	300
1902	100	100	100	300
1903	100	100	100	300
1904	100	100	100	300
1905	100	100	100	300
1906	100	100	100	300
1907	100	100	100	300
1908	100	100	100	300
1909	100	100	100	300
1910	100	100	100	300
1911	100	100	100	300
1912	100	100	100	300
1913	100	100	100	300
1914	100	100	100	300
1915	100	100	100	300
1916	100	100	100	300
1917	100	100	100	300
1918	100	100	100	300
1919	100	100	100	300
1920	100	100	100	300
1921	100	100	100	300
1922	100	100	100	300
1923	100	100	100	300
1924	100	100	100	300
1925	100	100	100	300
1926	100	100	100	300
1927	100	100	100	300
1928	100	100	100	300
1929	100	100	100	300
1930	100	100	100	300

Total 3000
 1900-1930

8. Yield

Data on yield of Thatcher, Hope, and Timstein sets of substitution lines are summarized in Tables 23, 24, and 25 respectively.

Accessory factors affecting yield such as drought, various diseases and insects, variable soil fertility, etc. were either not present or reduced to a minimum. Lodging and other characters such as kernel size, however, varied from line to line and may have affected yield. Despite the presence of some of these factors yields of individual lines were reasonably consistent from year to year as shown by the non-significance of the lines x years interaction (Table 58 of the Appendix).

All three donor varieties outyielded Chinese by 180 to 200%. None of the substitution lines were higher yielding than the critical donor variety, and several were lower (non significantly) than Chinese.

Granting that yield values of substitution lines exceeding the 5% level of significance are caused by genetic effects of transferred chromosomes, then three classes may be assumed: (I) those significantly higher yielding than Chinese, (II) those the same as or similar to Chinese, and (III) those significantly lower yielding than Chinese.

	Thatcher	Hope	Timstein
Significantly higher than Chinese.	I, III, VIII, XII	I, IV, V, VI, VII, VIII, IX, X, XII, XXI	I, II, III, IV, V, VI, VII, VIII, XII, XVI, XVII, XVIII, XIX, XXI
Same as or similar to Chinese.	II, IV, V, VI, VII, IX, X, XI, XIII, XV, XVI, XVIII, XIX, XX, XXI	II, III, XI, XV, XVI, XVII, XVIII, XIX, XX	IX, X, XI, XV, XX

None of the previously stated substitution lines were significantly lower yielding than Chinese.

In the class of chromosome lines that are not significantly different from Chinese, which includes 15 Thatcher, 9 Hope, and 5 Timstein chromosomes, it is quite likely that either there are no effective genes for this character on these chromosomes, or if there are, they have similar effects to genes in Chinese. Chromosomes XI, XV, and XX of all 3 donor varieties were not significantly different from Chinese. These chromosomes probably carry no differential genes affecting this character.

The number of lines that are significantly different varies with the donor varieties. Four Thatcher chromosomes I, III, VIII, and XII, ten Hope chromosomes I, IV, V, VI, VII, VIII, IX, X, XII, and XXI, gave lines significantly higher yielding than Chinese. Chromosome lines I, VIII, and XII of all 3 donor varieties were higher yielding than Chinese. In the set of substitution lines possessing Thatcher chromosomes, line one was the highest yielding (58.6% more than Chinese), however, it was not significantly different from lines three, eight, and twelve. In the Hope set of substitution lines, chromosomes I and XII are significantly higher yielding than chromosome lines, IV, V, VI, VII, VIII, IX, X, and XXI, which are not significantly different from each other. In the Timstein set the effects are still more variable. Chromosome I is significantly different from IV and XIX which in turn are significantly different from II, III, V, VI, VII, XVI, XVII, XVIII, and XXI. The latter group of chromosomes are not significantly different from each other. This signifies that different chromosomes of the same variety affect this character unequally, at times significantly so. In the Thatcher set the significantly different lines yielded 34.6 to 58.6% more than Chinese. Most of the Hope chromosome lines yield 19.7 to 37.0%

more than Chinese only I (45.9%) and XII (46.8%) yield higher. Ten of the fourteen Timstein chromosome lines yield 12 to 20% higher than Chinese while lines I, IV, VIII, and XIX yield 31 to 52% more than Chinese. Thatcher appears to possess a few major genes for yield while Hope and Timstein appear to carry minor genes mainly with only a few major genes. Chinese seems to have an accumulation of a large number of genes that give low yield, presumably recessives of dominant vigour genes.

The interaction, lines x varieties (Tables 59 and 60 of the Appendix), was highly significant and may be interpreted as meaning that some of the homologous chromosomes of different varieties are significantly different from each other in genetic effects. Chromosome XII is of this type. Chinese XII Thatcher yields 37.7% more than Chinese while Chinese XII Hope and Chinese XII Timstein yield 46.8 and 11.8% more, respectively -- a variation of 31% among different homologous chromosome XII lines. Other chromosomes with similar effects are IV, VII, IX, XI, XVI, and XIX.

Average yields of Chinese and Chinese lines with substituted Thatcher, Hope, and Timstein chromosomes are summarized in Table 26 together with L.S.D.'s for (a) lines within years within sets, (b) lines within sets, and (c) lines over years and sets.

On the basis of the results obtained it seems that yield is controlled by numerous genes located on at least 4 chromosomes in Thatcher, 10 in Hope, and 14 in Timstein.

Table 23

YIELDS OF THATCHER, CHINESE, AND CHINESE LINES WITH
SUBSTITUTED THATCHER CHROMOSOMES

Chromosome tested	1952	1953	1954	Average
Thatcher	1003.75 (150.5)	1205.00 (220.0)	832.50 (233.4)	1013.75 (193.6)
Chinese	667.00 (100.0)	547.50 (100.0)	356.70 (100.0)	523.73 (100.0)
1	908.75 (136.2)	1017.50 (185.8)	565.80 (158.6)	830.68 (158.6)
2	775.75 (116.3)	777.50 (142.0)	492.50 (138.1)	681.92 (130.2)
3	851.25 (127.6)	752.50 (137.4)	510.80 (143.2)	704.85 (134.6)
4	659.75 (98.9)	587.50 (107.3)	259.20 (72.7)	502.15 (95.8)
5	741.50 (111.2)	792.50 (144.7)	500.80 (140.4)	678.26 (129.5)
6	803.25 (120.4)	575.00 (105.0)	515.80 (144.6)	631.35 (120.5)
7	673.25 (100.9)	725.00 (132.4)	491.70 (137.8)	629.98 (120.3)
8	908.75 (136.2)	860.00 (157.1)	521.70 (146.3)	763.48 (145.8)
9	782.25 (117.3)	777.50 (142.0)	461.70 (129.4)	673.82 (128.7)
10	740.25 (110.3)	682.50 (124.7)	454.20 (127.3)	625.65 (119.5)
11	674.50 (101.1)	522.50 (95.4)	281.70 (79.0)	492.90 (94.1)
12	949.75 (142.4)	732.50 (133.7)	481.70 (135.0)	721.32 (137.7)
13		575.00 (105.0)	*277.50 (77.8)	426.25
15	806.50 (120.9)	532.50 (97.3)	403.30 (113.1)	580.77 (110.9)
16	444.25 (66.7)	567.50 (103.5)	407.50 (114.2)	473.08 (90.3)
18		570.00 (104.1)	*195.80 (54.9)	382.90
19	806.75 (121.0)	650.00 (118.7)	485.80 (136.2)	647.52 (123.6)
20	738.50 (110.7)	600.00 (109.5)	432.50 (121.3)	590.33 (112.7)
21	829.25 (124.3)	727.50 (132.9)	509.20 (142.8)	688.65 (131.5)
L.S.D. 5% level	149.40	66.07	67.39	183.9
1% level	198.90	87.81	89.11	246.7

* harvested when the lines were still green and immature

Values in brackets are yields in percentage of Chinese whose yield is taken as 100%.

Table 24

YIELDS OF HOPE, CHINESE, AND CHINESE LINES WITH
SUBSTITUTED HOPE CHROMOSOMES

Chromosome tested	1953		1954		Average	
Hope			675.8	(184.3)		
Chinese	602.5	(100.0)	366.7	(100.0)	484.6	(100.0)
1	875.0	(145.2)	539.2	(147.0)	707.1	(145.9)
2	627.5	(104.2)	476.7	(129.9)	552.1	(113.9)
3	645.0	(107.1)	486.7	(132.7)	565.9	(116.8)
4	662.5	(109.9)	497.5	(135.7)	580.0	(119.7)
5	735.0	(122.0)	499.2	(136.1)	617.1	(127.3)
6	747.5	(124.1)	510.8	(139.3)	629.2	(129.8)
7	807.5	(134.0)	521.7	(142.3)	664.6	(137.1)
8	770.0	(127.8)	505.8	(138.0)	637.9	(131.6)
9	750.0	(124.5)	501.7	(136.8)	625.9	(129.2)
10	727.5	(120.7)	517.5	(141.1)	622.5	(128.5)
11	552.5	(91.7)	371.7	(101.4)	462.1	(95.4)
12	877.5	(145.6)	545.0	(148.6)	711.3	(146.8)
15	625.0	(103.7)	466.7	(127.3)	545.9	(112.7)
16	567.5	(94.2)	379.2	(103.4)	473.4	(97.7)
17	627.5	(104.2)	467.5	(127.5)	547.5	(112.9)
18			445.0	(121.4)		
19	625.0	(103.7)	429.2	(117.0)	527.1	(108.8)
20	602.5	(100.0)	405.0	(113.2)	503.8	(104.0)
21	777.5	(129.0)	534.2	(145.7)	655.9	(135.3)
L.S.D. 5% level	67.87		64.42		82.78	
1% level	90.58		84.92		113.39	

Values in brackets are yields in percentage of Chinese whose yield is taken as 100%.

Table 1. Summary of the data for the 100 cases of the disease.

Age group		Sex		Race		Total
Male	Female	Male	Female	White	Black	
10-14	15	10	5	10	5	15
15-19	20	15	5	15	5	20
20-24	25	20	5	20	5	25
25-29	30	25	5	25	5	30
30-34	35	30	5	30	5	35
35-39	40	35	5	35	5	40
40-44	45	40	5	40	5	45
45-49	50	45	5	45	5	50
50-54	55	50	5	50	5	55
55-59	60	55	5	55	5	60
60-64	65	60	5	60	5	65
65-69	70	65	5	65	5	70
70-74	75	70	5	70	5	75
75-79	80	75	5	75	5	80
80-84	85	80	5	80	5	85
85-89	90	85	5	85	5	90
90-94	95	90	5	90	5	95
95-99	100	95	5	95	5	100
100-104	105	100	5	100	5	105
105-109	110	105	5	105	5	110
110-114	115	110	5	110	5	115
115-119	120	115	5	115	5	120
120-124	125	120	5	120	5	125
125-129	130	125	5	125	5	130
130-134	135	130	5	130	5	135
135-139	140	135	5	135	5	140
140-144	145	140	5	140	5	145
145-149	150	145	5	145	5	150
150-154	155	150	5	150	5	155
155-159	160	155	5	155	5	160
160-164	165	160	5	160	5	165
165-169	170	165	5	165	5	170
170-174	175	170	5	170	5	175
175-179	180	175	5	175	5	180
180-184	185	180	5	180	5	185
185-189	190	185	5	185	5	190
190-194	195	190	5	190	5	195
195-199	200	195	5	195	5	200
200-204	205	200	5	200	5	205
205-209	210	205	5	205	5	210
210-214	215	210	5	210	5	215
215-219	220	215	5	215	5	220
220-224	225	220	5	220	5	225
225-229	230	225	5	225	5	230
230-234	235	230	5	230	5	235
235-239	240	235	5	235	5	240
240-244	245	240	5	240	5	245
245-249	250	245	5	245	5	250
250-254	255	250	5	250	5	255
255-259	260	255	5	255	5	260
260-264	265	260	5	260	5	265
265-269	270	265	5	265	5	270
270-274	275	270	5	270	5	275
275-279	280	275	5	275	5	280
280-284	285	280	5	280	5	285
285-289	290	285	5	285	5	290
290-294	295	290	5	290	5	295
295-299	300	295	5	295	5	300
300-304	305	300	5	300	5	305
305-309	310	305	5	305	5	310
310-314	315	310	5	310	5	315
315-319	320	315	5	315	5	320
320-324	325	320	5	320	5	325
325-329	330	325	5	325	5	330
330-334	335	330	5	330	5	335
335-339	340	335	5	335	5	340
340-344	345	340	5	340	5	345
345-349	350	345	5	345	5	350
350-354	355	350	5	350	5	355
355-359	360	355	5	355	5	360
360-364	365	360	5	360	5	365
365-369	370	365	5	365	5	370
370-374	375	370	5	370	5	375
375-379	380	375	5	375	5	380
380-384	385	380	5	380	5	385
385-389	390	385	5	385	5	390
390-394	395	390	5	390	5	395
395-399	400	395	5	395	5	400
400-404	405	400	5	400	5	405
405-409	410	405	5	405	5	410
410-414	415	410	5	410	5	415
415-419	420	415	5	415	5	420
420-424	425	420	5	420	5	425
425-429	430	425	5	425	5	430
430-434	435	430	5	430	5	435
435-439	440	435	5	435	5	440
440-444	445	440	5	440	5	445
445-449	450	445	5	445	5	450
450-454	455	450	5	450	5	455
455-459	460	455	5	455	5	460
460-464	465	460	5	460	5	465
465-469	470	465	5	465	5	470
470-474	475	470	5	470	5	475
475-479	480	475	5	475	5	480
480-484	485	480	5	480	5	485
485-489	490	485	5	485	5	490
490-494	495	490	5	490	5	495
495-499	500	495	5	495	5	500
500-504	505	500	5	500	5	505
505-509	510	505	5	505	5	510
510-514	515	510	5	510	5	515
515-519	520	515	5	515	5	520
520-524	525	520	5	520	5	525
525-529	530	525	5	525	5	530
530-534	535	530	5	530	5	535
535-539	540	535	5	535	5	540
540-544	545	540	5	540	5	545
545-549	550	545	5	545	5	550
550-554	555	550	5	550	5	555
555-559	560	555	5	555	5	560
560-564	565	560	5	560	5	565
565-569	570	565	5	565	5	570
570-574	575	570	5	570	5	575
575-579	580	575	5	575	5	580
580-584	585	580	5	580	5	585
585-589	590	585	5	585	5	590
590-594	595	590	5	590	5	595
595-599	600	595	5	595	5	600
600-604	605	600	5	600	5	605
605-609	610	605	5	605	5	610
610-614	615	610	5	610	5	615
615-619	620	615	5	615	5	620
620-624	625	620	5	620	5	625
625-629	630	625	5	625	5	630
630-634	635	630	5	630	5	635
635-639	640	635	5	635	5	640
640-644	645	640	5	640	5	645
645-649	650	645	5	645	5	650
650-654	655	650	5	650	5	655
655-659	660	655	5	655	5	660
660-664	665	660	5	660	5	665
665-669	670	665	5	665	5	670
670-674	675	670	5	670	5	675
675-679	680	675	5	675	5	680
680-684	685	680	5	680	5	685
685-689	690	685	5	685	5	690
690-694	695	690	5	690	5	695
695-699	700	695	5	695	5	700
700-704	705	700	5	700	5	705
705-709	710	705	5	705	5	710
710-714	715	710	5	710	5	715
715-719	720	715	5	715	5	720
720-724	725	720	5	720	5	725
725-729	730	725	5	725	5	730
730-734	735	730	5	730	5	735
735-739	740	735	5	735	5	740
740-744	745	740	5	740	5	745
745-749	750	745	5	745	5	750
750-754	755	750	5	750	5	755
755-759	760	755	5	755	5	760
760-764	765	760	5	760	5	765
765-769	770	765	5	765	5	770
770-774	775	770	5	770	5	775
775-779	780	775	5	775	5	780
780-784	785	780	5	780	5	785
785-789	790	785	5	785	5	790
790-794	795	790	5	790	5	795
795-799	800	795	5	795	5	800
800-804	805	800	5	800	5	805
805-809	810	805	5	805	5	810
810-814	815	810	5	810	5	815
815-819	820	815	5	815	5	820
820-824	825	820	5	820	5	825
825-829	830	825	5	825	5	830
830-834	835	830	5	830	5	835
835-839	840	835	5	835	5	840
840-844	845	840	5	840	5	845
845-849	850	845	5	845	5	850
850-854	855	850	5	850	5	855
855-859	860	855	5	855	5	860
860-864	865	860	5	860	5	865
865-869	870	865	5	865	5	870
870-874	875	870	5	870	5	875
875-879	880	875	5	875	5	880
880-884	885	880	5	880	5	885
885-889	890	885	5	885	5	890
890-894	895	890	5	890	5	895
895-899	900	895	5	895	5	900
900-904	905	900	5	900	5	905
905-909	910	905	5	905	5	910
910-914	915	910	5	910	5	915
915-919	920	915	5	915	5	920
920-924	925	920	5	920	5	925
925-929	930	925	5	925	5	930
930-934	935	930	5	930	5	935
935-939	940	935	5	935	5	940
940-944	945	940	5	940	5	945
945-949	950	945	5	945	5	950
950-954	955	950	5	950	5	955
955-959	960	955	5	955	5	960
960-964	965	960	5	960	5	965
965-969	970	965	5	965	5	970
970-974	975	970	5	970	5	975
975-979	980	975	5	975	5	980
980-984	985	980	5	980	5	985
985-989	990	985	5	985	5	990
990-994	995	990	5	990	5	995
995-999	1000	995	5	995	5	1000
1000-1004	1005	1000	5	1000	5	1005
1005-1009	1010	1005	5	1005	5	1010
1010-						

Table 25

YIELDS OF TIMSTEIN, CHINESE, AND CHINESE LINES WITH
SUBSTITUTED TIMSTEIN CHROMOSOMES

Chromosome tested	1953		1954		Average	
Timstein	1087.50	(178.6)	828.33	(231.2)	957.92	(198.1)
Chinese	608.75	(100.0)	358.33	(100.0)	483.54	(100.0)
1	935.00	(153.6)	540.00	(150.7)	737.50	(152.5)
2	620.00	(101.8)	466.67	(130.2)	543.33	(112.4)
3	667.50	(109.7)	442.50	(123.5)	555.00	(114.8)
4	777.50	(127.7)	498.16	(136.5)	633.33	(131.0)
5	647.50	(106.4)	455.83	(127.2)	551.67	(114.1)
6	658.75	(108.2)	469.17	(130.9)	563.96	(116.6)
7	620.00	(101.8)	479.17	(133.7)	549.59	(113.7)
8	867.50	(142.5)	538.33	(150.2)	702.92	(145.4)
9	561.25	(92.2)	405.83	(113.3)	483.54	(100.0)
10	428.75	(70.4)	421.67	(117.7)	425.21	(87.9)
11	618.75	(101.6)	392.50	(109.5)	505.63	(104.6)
12	661.25	(108.6)	458.33	(127.9)	559.79	(115.8)
15	617.50	(101.4)	356.67	(99.5)	487.09	(100.7)
16	690.00	(113.3)	474.17	(132.3)	582.09	(120.4)
17	642.50	(105.5)	448.33	(125.1)	545.42	(112.8)
18	637.50	(104.7)	465.83	(130.0)	551.67	(114.1)
19	815.00	(133.9)	521.67	(145.5)	668.34	(138.2)
20	631.25	(103.7)	430.00	(120.0)	530.63	(109.7)
21	676.25	(111.1)	469.17	(130.9)	575.71	(118.4)
L.S.D. - 5% level	133.13		72.74		56.34	
1% level	177.29		96.19		76.56	

Values in brackets are yields in percentage of Chinese whose yield is taken as 100%.

Table 26

AVERAGE YIELDS OF CHINESE AND CHINESE LINES WITH
SUBSTITUTED THATCHER, HOPE, AND TIMSTEIN CHROMO-
SOMES IN 1953 AND 1954

Chromosome tested	THATCHER		HOPE		TIMSTEIN		THAT- CHER	HOPE	TIMS- TEIN	LINES
	1953	1954	1953	1954	1953	1954				
Chinese	547.5	340.0	602.5	380.0	608.8	340.0	443.8	491.2	474.4	469.8
1	1017.5	556.3	875.0	526.3	935.0	545.0	786.9	700.6	740.0	742.5
2	777.5	492.5	627.5	455.0	620.0	482.5	635.0	553.8	551.3	575.8
3	752.5	500.0	645.0	441.3	667.5	445.0	626.3	543.1	556.3	575.2
4	587.5	272.5	662.5	496.3	777.5	486.3	430.0	579.4	631.9	547.1
5	792.5	513.8	735.0	478.8	647.5	468.8	653.1	606.9	558.1	606.0
6	575.0	520.0	747.5	500.0	658.8	467.5	547.5	623.8	563.1	578.1
7	725.0	487.5	807.5	530.0	620.0	480.0	606.3	668.8	550.0	608.3
8	860.0	530.0	770.0	510.0	867.5	527.5	695.0	640.0	697.5	677.5
9	777.5	467.5	750.0	501.3	561.3	421.3	622.5	625.6	491.3	579.8
10	682.5	457.5	727.5	512.5	428.8	427.5	570.0	620.0	553.1	539.4
11	522.5	275.0	552.5	356.3	619.8	413.8	398.8	454.4	516.3	456.5
12	732.5	497.5	877.5	548.8	661.3	452.5	615.0	713.1	556.9	628.3
15	532.5	405.0	625.0	476.3	617.5	370.0	468.8	550.6	493.8	504.4
16	567.5	393.8	567.5	376.3	690.0	493.8	480.6	471.2	591.9	514.8
19	650.0	495.0	625.0	416.3	815.0	427.5	572.5	520.6	671.3	588.1
20	600.0	445.0	602.5	392.5	631.3	420.0	522.5	497.5	525.6	515.2
21	727.5	473.8	777.5	511.3	676.3	425.0	600.6	644.4	550.0	598.5
L.S.D. - 5% level	--		98.9				--	98.9		144.9
1% level	--		130.0				--	130.0		194.6

THE ... OF ...

No.	Date		Time		Place		Remarks		Total
	Month	Day	Hour	Min	Lat	Long	Wind	Sea	
1	Jan	1	10	00	10	10	10	10	10
2	Jan	2	10	00	10	10	10	10	10
3	Jan	3	10	00	10	10	10	10	10
4	Jan	4	10	00	10	10	10	10	10
5	Jan	5	10	00	10	10	10	10	10
6	Jan	6	10	00	10	10	10	10	10
7	Jan	7	10	00	10	10	10	10	10
8	Jan	8	10	00	10	10	10	10	10
9	Jan	9	10	00	10	10	10	10	10
10	Jan	10	10	00	10	10	10	10	10
11	Jan	11	10	00	10	10	10	10	10
12	Jan	12	10	00	10	10	10	10	10
13	Jan	13	10	00	10	10	10	10	10
14	Jan	14	10	00	10	10	10	10	10
15	Jan	15	10	00	10	10	10	10	10
16	Jan	16	10	00	10	10	10	10	10
17	Jan	17	10	00	10	10	10	10	10
18	Jan	18	10	00	10	10	10	10	10
19	Jan	19	10	00	10	10	10	10	10
20	Jan	20	10	00	10	10	10	10	10
21	Jan	21	10	00	10	10	10	10	10
22	Jan	22	10	00	10	10	10	10	10
23	Jan	23	10	00	10	10	10	10	10
24	Jan	24	10	00	10	10	10	10	10
25	Jan	25	10	00	10	10	10	10	10
26	Jan	26	10	00	10	10	10	10	10
27	Jan	27	10	00	10	10	10	10	10
28	Jan	28	10	00	10	10	10	10	10
29	Jan	29	10	00	10	10	10	10	10
30	Jan	30	10	00	10	10	10	10	10
31	Jan	31	10	00	10	10	10	10	10
32	Jan	32	10	00	10	10	10	10	10
33	Jan	33	10	00	10	10	10	10	10
34	Jan	34	10	00	10	10	10	10	10
35	Jan	35	10	00	10	10	10	10	10
36	Jan	36	10	00	10	10	10	10	10
37	Jan	37	10	00	10	10	10	10	10
38	Jan	38	10	00	10	10	10	10	10
39	Jan	39	10	00	10	10	10	10	10
40	Jan	40	10	00	10	10	10	10	10
41	Jan	41	10	00	10	10	10	10	10
42	Jan	42	10	00	10	10	10	10	10
43	Jan	43	10	00	10	10	10	10	10
44	Jan	44	10	00	10	10	10	10	10
45	Jan	45	10	00	10	10	10	10	10
46	Jan	46	10	00	10	10	10	10	10
47	Jan	47	10	00	10	10	10	10	10
48	Jan	48	10	00	10	10	10	10	10
49	Jan	49	10	00	10	10	10	10	10
50	Jan	50	10	00	10	10	10	10	10
51	Jan	51	10	00	10	10	10	10	10
52	Jan	52	10	00	10	10	10	10	10
53	Jan	53	10	00	10	10	10	10	10
54	Jan	54	10	00	10	10	10	10	10
55	Jan	55	10	00	10	10	10	10	10
56	Jan	56	10	00	10	10	10	10	10
57	Jan	57	10	00	10	10	10	10	10
58	Jan	58	10	00	10	10	10	10	10
59	Jan	59	10	00	10	10	10	10	10
60	Jan	60	10	00	10	10	10	10	10
61	Jan	61	10	00	10	10	10	10	10
62	Jan	62	10	00	10	10	10	10	10
63	Jan	63	10	00	10	10	10	10	10
64	Jan	64	10	00	10	10	10	10	10
65	Jan	65	10	00	10	10	10	10	10
66	Jan	66	10	00	10	10	10	10	10
67	Jan	67	10	00	10	10	10	10	10
68	Jan	68	10	00	10	10	10	10	10
69	Jan	69	10	00	10	10	10	10	10
70	Jan	70	10	00	10	10	10	10	10
71	Jan	71	10	00	10	10	10	10	10
72	Jan	72	10	00	10	10	10	10	10
73	Jan	73	10	00	10	10	10	10	10
74	Jan	74	10	00	10	10	10	10	10
75	Jan	75	10	00	10	10	10	10	10
76	Jan	76	10	00	10	10	10	10	10
77	Jan	77	10	00	10	10	10	10	10
78	Jan	78	10	00	10	10	10	10	10
79	Jan	79	10	00	10	10	10	10	10
80	Jan	80	10	00	10	10	10	10	10
81	Jan	81	10	00	10	10	10	10	10
82	Jan	82	10	00	10	10	10	10	10
83	Jan	83	10	00	10	10	10	10	10
84	Jan	84	10	00	10	10	10	10	10
85	Jan	85	10	00	10	10	10	10	10
86	Jan	86	10	00	10	10	10	10	10
87	Jan	87	10	00	10	10	10	10	10
88	Jan	88	10	00	10	10	10	10	10
89	Jan	89	10	00	10	10	10	10	10
90	Jan	90	10	00	10	10	10	10	10
91	Jan	91	10	00	10	10	10	10	10
92	Jan	92	10	00	10	10	10	10	10
93	Jan	93	10	00	10	10	10	10	10
94	Jan	94	10	00	10	10	10	10	10
95	Jan	95	10	00	10	10	10	10	10
96	Jan	96	10	00	10	10	10	10	10
97	Jan	97	10	00	10	10	10	10	10
98	Jan	98	10	00	10	10	10	10	10
99	Jan	99	10	00	10	10	10	10	10
100	Jan	100	10	00	10	10	10	10	10

V. DISCUSSION

The use of substitution lines, as employed in this study, is a new approach to the genetic study of quantitative characters. This method is advantageous where classification of segregants is difficult or impossible and where minor or modifying genes are operating. Hemizygous ineffective recessive genes if present can exert their effect in this material. Although no qualitative characters, such as seed colour, were studied this method is also applicable to such analyses. Since substitution lines can be increased as varieties, tests for as many characters as desired can be carried out. In this study eight characters were tested.

The association of a number of tentative genes on a specific chromosome, as derived from this study, may be considered as a tentative linkage group. These groups have been summarized in Tables 27, 28, and 29. Although linear arrangements within the linkage groups cannot be determined by this method, nevertheless, these genes are linked. This information may be used as a basis for further and more precise linkage studies of these characters. The reason why an indefinite number of genes may be associated with a specific chromosome using substitution lines is that genes are tested against chromosomes and not against linkage testers as used in conventional methods. Thus genes may be found to be linked even though they are more than 50 cross-over units apart.

1. Methods

The establishment of substitution lines entails a considerable amount of cytological work. It is necessary to ascertain the exact chromosomal constitution of both male and female plants at every backcross

generation. Univalent shift in monosomic plants may result in the establishment of a substitution line for a chromosome which has shifted from the bivalent to the univalent condition or it may cause a delay in substitution due to the necessity of discarding the plant material and initiating the program again. This may happen when the members of one or more homologous pairs of chromosomes fail to conjugate or separate precociously. At metaphase, if only one pair of chromosomes is involved, the two homologous univalents may go to one pole and the critical univalent to the other. A gamete of the latter type, if fertilized by a gamete containing the normal complement of chromosomes (21') would result in an individual monosomic for a different chromosome. If monosomics are employed, and they are as males in every backcross generation in producing substitution lines, plants with one univalent only should be used. These plants should be crossed from time to time (best every generation) to standard lines to determine if they are aneuploid for the critical chromosome. Before the program of producing substitution lines is initiated, the donor parent plants to be used in crossing to the nullisomics, monotelosomics, or monoisosomics should be cytologically analyzed to check for presence of chromosomal abnormalities and plants with 21 pairs of chromosomes only should be used.

The number of backcrosses to use in establishing substitution lines may be open to debate. By the fifth backcross generation, approximately 97% of the genes on the 20 chromosomes (excluding the one being transferred) of the non-recurrent parent have been reconstituted. If 3% of the genes at the fifth backcross are in the heterozygous condition there is a possibility that the characters being studied may show heterotic effects, though slight in self pollinated crops as common wheat,

and erroneous conclusions could be drawn for the character(s) in question. Therefore it may be desirable to backcross for more, probably seven, generations at which time the percentage of genes from the non-recurrent parent will be only approximately 1% and the possibility of heterosis occurring would be almost completely eliminated.

2. Experimental Results

The use of substitution lines simplifies and facilitates considerably the genetic analyses of characters controlled by multiple genes. Each of 19 Thatcher, 16 Hope and 19 Timstein chromosomes were shown to have some effect on at least one character.

Awning was found to be conditioned by genes located on 5 Thatcher, 2 Hope and 3 Timstein chromosomes. The results for chromosomes VIII, IX, and X substantiate previous findings (Sears 71, Unrau 102, O'Mara 58). The association of genes with chromosomes III of Thatcher and Timstein and IV, XII, and XXI of Thatcher was not expected on the basis of previous information. To account for the appearance of awning in substitution lines III, IV, XII, and XXI, an extension of the present theory is proposed (see IV. 1, above). To determine whether a single gene may be responsible for a chromosome's action and whether the gene action is dominant or recessive, crosses may be made between each of the substitution lines III, IV, XII, and XXI and the recipient variety. Only genes on one chromosome pair will segregate. If F_1 plants are awnless then Chinese carries the dominant alleles and if F_1 plants are awned then awn promoting genes are dominant and Chinese possesses recessive alleles. F_2 segregation would show whether one or more genes were operating in conditioning awning. Similar types of crosses between any substitution line and the recipient parent may be made for any character to determine whether one or more genes are responsible for a chromosome's action.

Studies of earliness (IV. 2., above) indicate that time of heading is conditioned by two types of genes: (a) those that differentiate summer and winter growth habits and (b) those that modify the expression of growth habit genes to a greater or lesser extent. Unrau (102) associated

one recessive gene for winter growth in Hymar with chromosome IX. Two other genes for winter growth habit have been associated in this study, with chromosomes XIII and XVIII of Thatcher. Therefore alleles at at least 3 loci condition winter growth habit. The modifying genes appear to be multiple and of varying strengths. Ten chromosomes each of Thatcher and Hope, and 13 of Timstein have significant enhancing effects.

Genes on 3 Thatcher, 6 Hope, and 1 Timstein chromosome appear to have a marked effect on plant height (IV. 3., above). Increase in plant height is due to a gene or genes on chromosome XI of Thatcher, Chromosomes I, III, VII, IX, and XII of Hope, VIII of Thatcher, Hope, and Timstein, and XVI of Thatcher seem to possess genes reducing plant height of Chinese. These results substantiate (indirectly) previous findings of Goulden (30), Thompson (99), and Sears (71).

From results of other investigators and those of this study, (IV. 6., above) it seems that two types of genes, which may be classified as major and minor or modifying genes, condition spike density in 21" chromosome wheats. Major genes differentiate between dense and lax spikes as in interspecific crosses between compactum and vulgare wheats. In intraspecific crosses the degree of density depends on minor or modifying genes. Since substitution lines were produced using only intraspecific varieties, only minor gene differences would be expected on the basis of this assumption. The results obtained substantiate the assumption. Chromosomes IV of Thatcher, II of Hope, and XII of Timstein increased significantly spike density of Chinese; eight Thatcher, three Hope, and eleven Timstein chromosomes reduced Chinese spike density. The minor or modifying genes on different chromosomes within varieties gave in certain comparisons significantly different genetic effects. That substitution lines may be used in analyzing characters for minor

or modifying genes seems to be supported by results for this character.

Studies of lodging, protein content, thousand-kernel weight and yield (IV. 5, 4, 7, 8, above) reveal that numerous chromosomes condition the expression of these characters. In contrast to characters such as awning, earliness, and spike density which are conditioned by both major genes with large effects and minor genes with small effects, these characters, together with plant height, seem to be controlled by the joint action of a large number of genes, each with a small effect. Although the individual effects of these polygenes are similar they are not necessarily equal. Protein content in Thatcher was found to be conditioned by 5 chromosomes. The genetic effects of these chromosomes were apparently equal. Lodging was conditioned by 15 Thatcher, 13 Hope, and 9 Timstein chromosomes; the effects of chromosomes within varieties were not always equal. The same was true for chromosomal effects for thousand-kernel weight and yield. Kernel weight was conditioned by 3 Thatcher, 3 Hope and 5 Timstein chromosomes. The number of chromosomes affecting yield was large, 4 in Thatcher, 10 in Hope, and 14 in Timstein. The genetic effects of individual chromosomes were more variable for this character than for any other.

Since whole chromosomes are being tested, it is impossible, before further work is carried out, to predict whether the chromosome effect on any character is due to one or more genes. Where substitution lines are not significantly different from Chinese this similarity may be due to absence of pertinent genes on chromosomes concerned or similarity of alleles in both the recipient and donor varieties. Where differences are significant this may be due to one or more differential genes per chromosome. If one gene conditions a character it may have one, two, or a series of alleles. If two or more genes per chromosome

condition a character they also may have one, two or a series of alleles each and the situation becomes increasingly difficult to analyze. If multiple alleles exist and two or more genes affecting a particular character are carried by any one chromosome, testing may reveal no more than the expression of the particular genic combination of the transferred chromosome.

For earliness, height, lodging, spike density, and yield, it was possible to calculate a lines x varieties interaction which in all cases was highly significant. These significant values show that genetic effects of some of the homologous chromosomes of different varieties are significantly different genetically and may support either of two alternatives: (a) the action of a chromosome is due to one gene with two or a series of alleles for each, the alleles being carried by homologous chromosomes of different varieties; or (b) the action of a chromosome is due to more than one gene and the transferred chromosome has a combination of genes different from that of its Chinese homologue.

Since numerous genes condition certain characters, their multiplicity may have originated in the following ways. Duplication or even triplication is thought to be the main cause for a high degree of multiplicity. Gene and chromosomal mutations also may be responsible for adding genes to a polygenic system. Mutations of duplicate or even triplicate genes are probably the cause of multiple allelic series.

On the basis of results, there is considerable promise that the chromosome substitution method will permit a more adequate understanding of the genetics of quantitative characters. It appears that by transferring whole chromosomes it should be possible to improve existing varieties with genes for desirable characters from other varieties without going through testing procedures until the transfer is completed. Such

a method would permit the breeding of such characters as rust resistance without rust nurseries. Whether whole chromosome substitution will become a useful method of plant breeding depends on: (a) the autonomous or non-autonomous action of genes in different genic milieu, and (b) sufficiency of fairly easily transferrable characters. The larger the number of genes involved in conditioning a particular character, the more difficult it would be to transfer the character and thus the less useful the method as a plant breeding tool.

VI SUMMARY

Thatcher, Hope, and Timstein substitution lines were tested to determine the association between the various chromosomes and the characters, awning, earliness, height, lodging, protein content, spike density, thousand-kernel weight, and yield.

1. Awning was apparently conditioned by 2 genes in Hope, 3 in Timstein, and 5 in Thatcher. In Hope, the recessive alleles hd and b_2 of the two awn-inhibiting genes of Chinese were associated with chromosomes VIII and X; chromosome IX also possesses b_1 as does Chinese. Timstein also appears to carry the alleles hd and b_2 on chromosome VIII and X; chromosome IX carries the dominant awn-inhibiting gene B_1 or a slightly less effective allele B_1^a . An awn promoting gene (K or k) was associated with chromosome III of Timstein. Thatcher carries hd or Hd^a on VIII, b_1^a on IX and b_2 on X. The appearance of awned types in lines III, IV, XII, and XXI was not expected to the basis of published information; a hypothesis is proposed to explain the results. Chromosomes III, IV, and XXI may carry either dominant or recessive awn-promoting alleles.

2. Earliness was conditioned by 2 types of genes: (a) those differentiating summer and winter growth habit, and (b) those modifying the expression of each gene type in (a). Chinese, Hope, and Timstein each carry summer growth habit genes on chromosomes XIII and XVIII; Thatcher carries winter growth habit genes on these chromosomes possibly at the same loci. Genes on Thatcher chromosomes I, II, III, V, VI, VIII, IX, XII, XXI, Hope chromosomes II, III, IV, V, VII, IX, X, XII, XVIII, XXI, and Timstein chromosomes II, III, IV, VI, V, VII, VIII, IX, XII, XVII, XVIII, XIX, and XX modified more or less the earliness of Chinese. The modifications were all in the direction of enhanced earliness.

3. Eight genes or groups of genes seem to condition plant height. Chromosome XI of Thatcher was associated with significant height increase. Chromosomes I, III, VII, IX, and XII of Hope, VIII of Thatcher, Hope and Timstein and XVI of Thatcher were associated with significant height decrease of Chinese.

4. Thatcher chromosomes I, II, III, IV, V, VI, VII, VIII, IX, XII, XIII, XVI, XIX, XX, XXI, Hope chromosomes I, II, III, IV, V, VI, VII, VIII, IX, XII, XVII, XIX, XX, and Timstein chromosomes I, IV, VIII, V, IX, X, XV, XVIII, and XIX each produced lines significantly more resistant to lodging than Chinese. The different chromosomes within any set of substitution lines do not effect lodging equally. Chromosomes with major and minor genetic effects appear to be present. None of the substitution lines of either of the three sets were significantly lower than Chinese in lodging resistance.

5. Protein content of Thatcher was found to be conditioned by genes associated with chromosomes V, VII, IX, XV, and XVI. These chromosomes were associated with a significant increase in protein content in their respective Chinese lines.

6. Differences in spike density between the donor varieties Thatcher, Hope, and Timstein and the recipient variety of Chinese were due to minor or modifying genes; no major gene differences were obtained. These modifying genes which were associated with Thatcher chromosomes I, III, IV, VI, VIII, IX, X, XIX, XXI, Hope chromosomes II, VIII, X, XX, and Timstein chromosomes III, V, VI, VII, VIII, X, XI, XII, XVI, XIX, XX, and XXI showed varying degrees of effects.

7. At least 7 chromosomes, I, V, XVI, of Thatcher, I, IV, VI, of Hope, and I, V, VI, X, XIX, of Timstein condition kernel weight. Chromosome lines I, IV, V, VI, X, and XIX, were associated with a significant increase in kernel weight over Chinese. Chinese XVI Thatcher lines were significantly lower than Chinese. Chromosome I had the greatest effect, involving all three donor varieties in every case kernel size was significantly increased.

8. Yield was conditioned by Thatcher chromosomes I, III, VIII, XII, Hope chromosomes IV, V, VI, VII, VIII, IX, X, XII, XXI, and Timstein chromosomes I, II, III, IV, V, VI, VII, VIII, XII, XVI, XVII, XVIII, XIX and XXI. Chromosome lines within each of the three sets of substitution lines showed both major and minor genetic effects. Significantly higher yielding lines gave yield increases over Chinese ranging from 12.0 to 58.6 per cent.

9. The advantages and limitations of substitution lines for cytogenetic studies and plant breeding are discussed.

TABLE 27

ASSOCIATION OF INDIVIDUAL THATCHER CHROMOSOMES WITH THE CHARACTERS STUDIED

Chromosome tested		Awning	Earliness	Height	Lodging	Protein Content	Spike Density	1,000- Kernel Weight	Yield
1.	*S.H.		+		+			+	+
	**S.L.						+		
2.	S.H.		+		+				
	S.L.								
3.	S.H.	+	+		+				+
	S.L.						+		
4.	S.H.	+			+		+		
	S.L.								
5.	S.H.		+		+	+		+	
	S.L.								
6.	S.H.		+		+				
	S.L.						+		
7.	S.H.		+		+	+			
	S.L.								
8.	S.H.	+	+		+				+
	S.L.			+			+		
9.	S.H.	+	+		+	+			
	S.L.						+		
10.	S.H.	+							
	S.L.						+		
11.	S.H.			+					
	S.L.								
12.	S.H.	+	+		+				+
	S.L.								
13.	S.H.				+				
	S.L.		+						
15.	S.H.		+			+			
	S.L.								
16.	S.H.				+	+			
	S.L.			+				+	
18.	S.H.								
	S.L.		+						
19.	S.H.				+				
	S.L.						+		
20.	S.H.				+				
	S.L.								
21.	S.H.	+			+				
	S.L.						+		

* Significantly Higher - S.H.

** Significantly Lower - S.L.

TABLE 28

ASSOCIATION OF INDIVIDUAL HOPE CHROMOSOMES WITH THE CHARACTERS STUDIED

Chromosome tested		Awning	Earliness	Height	Lodging	Spike Density	1,000- Kernel Weight	Yield
1.	*S.H.				+		+	+
	**S.L.			+				
2.	S.H.		+		+	+		
	S.L.							
3.	S.H.		+		+			
	S.L.			+				
4.	S.H.		+		+		+	+
	S.L.							
5.	S.H.		+		+			+
	S.L.							
6.	S.H.				+		+	+
	S.L.							
7.	S.H.		+		+			+
	S.L.			+				
8.	S.H.	+		+	+	+		+
	S.L.			+				
9.	S.H.		+		+			+
	S.L.			+				
10.	S.H.	+	+					+
	S.L.					+		
11.	S.H.							
	S.L.							
12.	S.H.		+		+			+
	S.L.			+				
15.	S.H.							
	S.L.							
16.	S.H.							
	S.L.							
17.	S.H.				+			
	S.L.							
18.	S.H.		+					
	S.L.							
19.	S.H.				*			
	S.L.							
20.	S.H.				+			
	S.L.					+		
21.	S.H.		+					+
	S.L.							

* Significantly Higher - S.H.

** Significantly Lower - S.L.

TABLE 29

ASSOCIATION OF INDIVIDUAL TIMSTEIN CHROMOSOMES WITH THE CHARACTERS STUDIED

Chromosome tested		Awning	Earliness	Height	Lodging	Spike Density	1,000- Kernel Weight	Yield
1.	*S.H.				+		+	+
	**S.L.							
2.	S.H.		+					+
	S.L.							
3.	S.H.	+	+			+		+
	S.L.							
4.	S.H.		+		+			+
	S.L.							
5.	S.H.		+		+	+	+	+
	S.L.							
6.	S.H.		+			+	+	+
	S.L.							
7.	S.H.		+			+		+
	S.L.							
8.	S.H.	+	+		+	+		+
	S.L.			+				
9.	S.H.		+		+			
	S.L.							
10.	S.H.	+			+	+	+	
	S.L.							
11.	S.H.					+		
	S.L.							
12.	S.H.		+			+		+
	S.L.							
15.	S.H.				+			
	S.L.							
16.	S.H.					+		+
	S.L.							
17.	S.H.		+					+
	S.L.							
18.	S.H.		+		+			+
	S.L.							
19.	S.H.		+		+	+	+	+
	S.L.							
20.	S.H.		+			+		
	S.L.							
21.	S.H.					+		+
	S.L.							

* Significantly Higher - S.H.

** Significantly Lower - S.L.

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IX. APPENDIX

Table 1

Computation of lines x years interaction of earliness from composite of
3 sets of substitution lines in 1953 and 1954.

Chromosome tested	Tatcher						Hope						Timstein					
	*1954 ¹			*1954 ²			1954 ¹			1954 ²			1954 ¹			1954 ²		
	Rep 1	Rep 2	Rep 1	Rep 2	Rep 1	Rep 2	Rep 1	Rep 2	Rep 1	Rep 2	Rep 1	Rep 2	Rep 1	Rep 2	Rep 1	Rep 2	Rep 1	Rep 2
Chinese Spring	65	65	69	67	66	66	65	65	67	67	67	67	65	67	68	68	66	66
1	58	67	62	62	63	63	64	63	66	66	66	66	66	67	68	68	66	66
2	58	59	64	63	64	64	55	55	62	62	64	64	60	65	64	64	68	67
3	57	57	62	62	63	63	54	54	61	62	62	62	63	66	67	67	65	64
4	64	63	68	69	66	67	59	59	64	62	66	65	63	66	67	67	65	66
5	59	59	63	63	64	64	57	57	62	63	64	65	61	63	63	63	63	64
6	57	57	63	62	63	63	60	62	65	65	63	65	61	62	62	62	63	64
7	59	58	64	64	63	64	50	50	59	60	60	60	63	62	67	67	65	65
8	58	58	63	63	63	63	64	64	66	66	65	65	61	61	62	62	64	64
9	61	61	67	68	63	63	53	53	62	62	62	62	62	62	65	65	69	67
10	62	63	68	68	66	66	53	53	62	61	62	62	62	65	67	67	70	70
11	65	65	68	68	66	67	63	63	67	67	68	67	63	67	66	66	66	66
12	57	57	62	62	63	63	55	55	63	63	63	64	60	62	62	62	63	63
15	64	63	66	67	66	66	61	62	67	67	66	66	64	65	68	67	67	67
16	64	64	66	66	66	66	63	63	68	67	66	67	66	68	67	67	66	66
19	62	63	67	67	66	67	64	65	67	67	73	73	64	67	65	65	65	66
20	61	60	66	66	64	64	65	65	66	67	65	65	63	62	64	64	64	63
21	63	62	66	66	66	66	56	55	61	62	64	64	65	67	67	67	67	67

Table 1 (continued)

Source of Variation	df	Analysis of Variance				
		<u>ss</u>	<u>ms</u>	<u>F</u>	<u>5%</u>	<u>1%</u>
Total	323	3834.8				
Reps	1	1.6	1.6			
Varieties	2	210.4	105.2			
Years	2	1193.0	596.5			
YxV	4	117.6	29.4			
Error (1)	8	2.7	0.3			
Lines	17	998.8	58.8			
LxY	34	204.5	6.0	0.25	1.77	2.25
LxV	34	808.1	23.8	7.68 ^{xx}	1.60	1.94
LxYxV	68	208.9	3.1	6.89 ^{xx}	1.38	1.58
Error (2)	153	69.2	0.45			
		<u>LxYxV</u>	<u>LxV</u>	<u>L</u>		
L.S.D.	5% level	1.325	1.996	3.314		
	1% level	1.752	2.651	4.450		

*1954¹ test at Edmonton*1954² test at Brooks

Computation of lines x varieties interaction of earliness from composite of 3 sets of substitution lines in 1953.

Chromosome tested	Hope	Ave.	Timbstein	Thatcher (1)	Ave.	Ave.
Chinese Spring	67	67	66	66	66	66.25
1	67	66	66	66	65	66.25
2	64	65	68	67	64	64.00
3	62	63	65	64	63	63.00
4	66	65	65	66	66	66.25
5	64	65	63	64	64	64.00
6	63	65	63	63	63	63.00
7	60	60	65	63	64	63.75
8	65	66	64	64	64	63.50
9	62	62	69	67	63	63.00
10	62	63	70	70	66	66.00
11	68	66	66	66	67	66.75
12	63	64	63	62	63	63.00
15	66	65	67	67	65	65.50
16	66	67	66	66	66	66.25
19	73	73	65	65	67	66.75
20	65	65	64	63	64	64.00
21	64	63	67	66	66	66.00
Analysis of Variance						
Source	df	ss	ms	F		
Total	215	9154000.0				0.01
Reps	3	1.4	0.47			
Varieties	2	40.4	20.20			
Error (1)	6	4.7	0.78			
Lines	17	419.6	24.68			
Lines x varieties	34	462.1	13.59			
Error (2)	153	50.9	0.33			
L.S.D.	5% level = 0.80					
	1% level = 1.06					

Computation of lines x varieties interaction of earliness from composite of 3 sets of substitution lines in 1954 at Edmonton.

Chromosome tested	Hope	Ave.	Timstein	Ave.	Thatcher	Ave.
Chinese Spring						
1	65	65.0	65	65	65	65.0
2	64	63.5	64	66	58	57.5
3	55	55.0	62	60	58	58.5
4	53	53.5	62	63	57	57.0
5	58	58.5	64	63	64	63.5
6	57	58.0	61	61	59	59.0
7	60	61.0	61	61	57	57.0
8	50	50.0	63	62	59	58.5
9	63	63.5	61	61	58	58.0
10	53	53.0	63	62	61	61.0
11	53	53.0	62	62	62	62.5
12	62	62.5	62	63	65	65.0
13	55	55.5	60	60	57	57.0
14	61	61.5	64	65	64	63.5
15	62	63.0	66	66	64	64.0
16	63	63.0	66	66	64	64.0
17	58	58.5	61	62	90	90.0
18	64	64.5	64	63	62	62.5
19	65	65.0	63	62	60	60.5
20	64	64.5	63	62	61	61.0
21	56	55.5	65	66	63	62.5

Analysis of Variance				
Source	df	ss	ms	F
Total	113	428597.4		
Reps	1	0.3	0.30	
Varieties	2	332.6	166.30	
Error (1)	2	2.1	1.05	
Lines	18	1119.6	62.20	
Lines x varieties	36	1707.4	47.43	
Error (2)	54	20.6	0.38	
				124.82xx
				1.64
				2.00

L.S.D.
5% level = 1.24
1% level = 1.65

Computation of lines x varieties interaction of earliness from composite of 3 sets of substitution lines in 1954 at Brooks.

Chromosome	tested	Hope	Ave.	Timstein	Ave.	Thatcher	Ave.
Chinese	67	67	67	67	67	67	67
Spring	66	66	66	67	67	67	67
1	62	62	62	64	64	62	62
2	61	62	62	66	67	62	62
3	64	62	62	66	67	62	62
4	62	63	62	63	63	68	68
5	65	65	65	62	63	63	63
6	59	60	60	67	65	64	63
7	66	66	66	61	62	63	62
8	62	62	62	64	65	67	67
9	62	61	62	65	67	68	67
10	67	67	67	67	67	68	67
11	63	63	62	62	62	62	62
12	67	67	67	68	67	66	66
15	68	67	67	68	67	67	67
16	62	61	62	62	62	66	66
18	67	67	67	65	66	67	67
19	66	67	67	64	64	66	65
20	61	62	62	67	67	66	65
21							

Source	df	ss	ms
Total	341		
Reps	5	3.8	0.76
Varieties	2	233.0	116.5
Error (1)	10	11.2	1.12
Lines	18	1501.4	83.4
Lines x varieties	36	3227.1	89.6
Error (2)	270	78.4	0.29
L.S.D.	5% level - 0.62		
	1% level - 0.82		

TABLE 4
Chinese Spring lines with substituted Thatcher chromosomes.

1952

Chromosome tested	Earliness				Average
	Series 1	Series 2	Series 3	Series 4	
Chinese Spring	69	69	69	69	69.0
Thatcher	63	63	63	63	63.0
1	64	65	64	64	64.25
2	66	66	66	66	66.0
3	64	64	64	64	64.0
4	68	68	68	68	68.0
5	66	66	66	66	66.0
6	64	65	65	65	64.75
7	66	66	66	66	66.0
8	65	65	66	65	65.25
9	64	64	64	64	64.0
10	66	66	66	66	66.0
11	69	69	69	68	68.75
12	64	64	64	65	64.25
15	66	66	66	66	66.0
16	72	72	72	72	72.0
17	68	68	68	68	68.0
19	68	68	68	68	68.0
20	66	66	66	67	66.25
21	68	69	68	69	68.50

Source	D.F.	Analysis of Variance				5%	1%
		S.S.	M.S.	F			
Total	79	377					
Reps	3	0	0				
Lines	19	372	19.6	217.7 ^{xx}	1.77	2.25	
Error	57	5	0.09				

$$\text{L.S.D. (1) } 5\% - t_{.05} \times \sqrt{\frac{2 \times .09}{4}} = 0.424424$$

$$(11) 1\% - t_{.01} \times \sqrt{\frac{2 \times .09}{4}} = .212 \times 2.666 = 0.565192$$

TABLE 5

Chinese Spring lines with substituted Thatcher chromosomes.

	<div style="text-align:center;">Earliness</div>					1953
Chromosome tested	Series 1	Series 2	Series 3	Series 4	Average	
Thatcher	61	61	61	61	61.00	
Chinese Spring	66	66	66	67	66.25	
1	63	63	63	63	63.00	
2	64	64	64	64	64.00	
3	63	63	63	63	63.00	
4	66	67	66	66	66.25	
5	64	64	64	64	64.00	
6	63	63	63	63	63.00	
7	63	64	64	64	63.75	
8	63	63	64	64	63.50	
9	63	63	63	63	63.00	
10	66	66	66	66	66.00	
11	66	67	67	67	66.75	
12	63	63	63	63	63.00	
13	77	78	77	79	77.75	
15	66	66	65	65	65.50	
16	66	66	66	67	66.25	
17	66	66	67	66	66.25	
18	83	83	83	83	83.00	
19	66	67	67	67	66.75	
20	64	64	64	64	64.00	
21	66	66	66	66	66.00	
<div style="text-align:center;"><u>Analysis of Variance</u></div>						
<u>Source</u>	<u>df</u>	<u>ss</u>	<u>ms</u>	<u>F</u>	<u>5%</u>	<u>1%</u>
Total	87	2098				
Reps	3	1.2	0.40	2.86		
Lines	21	2088	99.43	710 ^{xxx}	1.73	2.17
Error	63	8.8	0.14			
L.S.D.	- 5% point = .26 x 2.001 = 0.520					
	1% point = .26 x 2.663 = 0.692					

TABLE 6

Chinese Spring lines with substituted Thatcher chromosomes.

Earliness							1954
Chromosome tested	Series 1	Series 2	Series 3	Series 4	Series 5	Series 6	Average Total
Thatcher	59	59	58	58	59	59	58.7 352
Chin. Spring	69	67	67	68	67	67	67.5 405
1	62	62	62	62	62	61	61.8 371
2	64	63	62	62	62	62	62.5 375
3	62	62	62	62	62	62	62.0 372
4	68	69	68	68	68	68	68.1 409
5	63	63	63	62	63	63	62.8 377
6	63	62	63	63	62	62	62.5 375
7	64	64	63	63	63	63	63.3 380
8	63	63	62	61	62	61	62.0 372
9	67	68	67	67	66	66	66.8 401
10	68	68	67	67	67	67	67.3 404
11	68	68	68	68	67	67	67.7 406
12	62	62	62	61	62	61	61.7 370
13	88	88	88	88	88	88	88.0 528
15	66	67	66	66	66	65	66.0 396
16	66	66	67	67	67	66	66.5 399
18	88	88	88	88	88	88	88.0 528
19	67	67	66	66	67	66	66.5 399
20	66	66	65	65	65	66	65.5 393
21	66	66	65	65	65	65	65.3 392
22(10)	67	68	67	67	66	67	67.0 402
23(16)	65	65	65	65	66	66	65.3 392
24(19)	67	67	67	67	67	68	67.1 403
Tim.	57	56	57	57	56	56	56.5 339

Analysis of Variance

<u>Source</u>	<u>df</u>	<u>ss</u>	<u>ms</u>	<u>F</u>	<u>5%</u>	<u>1%</u>
Total	149	7455.4				
Reps	5	7.9	1.58			
Lines	24	7417.4	309.1	1236.4	1.61	1.95
Error	120	30.1	.25			

L.S.D. - 5% point-1.962 x .29 = 0.475

- 1% point-2.621 x .29 = 0.760

TABLE 7

Chinese Spring lines with substituted Thatcher chromosomes.

1954

				1954		
Chromosome tested	Earliness		Total	Average		
	Series 1	Series 2				
Thatcher	54	54	108	54.0		
Chinese Spring	65	65	130	65.0		
1	58	57	115	57.5		
2	58	59	117	58.5		
3	57	57	114	57.0		
4	64	63	127	63.5		
5	59	59	118	59.0		
6	57	57	114	57.0		
7	59	58	117	58.5		
8	58	58	116	58.0		
9	61	61	122	61.0		
10	62	63	125	62.5		
11	65	65	130	65.0		
12	57	57	114	57.0		
13	90	90	180	90.0		
15	64	63	127	63.5		
16	64	64	128	64.0		
18	90	90	180	90.0		
19	62	63	125	62.5		
20	61	60	121	60.5		
21	63	62	125	62.5		
22(10)	62	63	125	62.5		
23(16)	63	64	127	63.5		
24(19)	63	63	126	63.0		
Analysis of Variance						
Source	df	ss	ms	F	5%	1%
Total	47	3654				
Reps	1	0				
Lines	23	3548.5	154.2	230.2**	2.01	2.72
Error	23	15.5				
L.S.D. 5% point - $2.00 \times \sqrt{2 \times .67} = .66 \times 2.07 = 1.36$ 1% point - $2.66 \times \sqrt{2 \times .67} = .66 \times 2.81 = 1.85$						

TABLE 8

Chinese Spring lines with substituted Hope chromosomes.

1953

Chromosome tested	Earliness				Average
	Series 1	Series 2	Series 3	Series 4	
*Hope	67	67	67	67	67.00
Chinese Spring	67	67	67	66	66.75
1	67	66	67	66	66.50
2	64	64	65	64	64.25
3	62	62	63	62	62.25
4	66	65	64	64	64.25
5	64	65	65	64	64.50
6	63	65	65	65	64.50
7	60	60	60	60	60.00
8	65	65	66	65	65.25
9	62	62	62	63	62.25
10	62	62	62	63	62.25
11	68	67	66	66	66.75
12	63	64	64	64	63.75
15	66	66	65	65	65.50
16	66	67	67	66	66.50
17	67	66	66	66	66.25
*19	73	73	73	73	73.00
20	65	65	65	65	65.00
21	64	64	63	64	63.75

* germinated approximately 8 days later than other lines

Source	df	Analysis of Variance			5%	1%
		SS	MS	F		
Total	79	549				
Reps	3	1	0.333	1.05		
Lines	19	530	27.8	88.0 ^{xxx}	1.77	2.25
Error	57	18	0.316			
L.S.D.	(1) 5% - $t_{.05} \times \sqrt{\frac{2 \times .316}{4}} = 2.002 \times 0.396 = .792792$					
	(11) 1% - $t_{.01} \times \sqrt{\frac{2 \times .316}{4}} = 2.666 \times 0.396 = 1.055736$					

TABLE 9

Chinese Spring lines with substituted Hope chromosomes

Chromosome tested	Series 1	Earliness			Total	1954
		Series 2	Series 3	Series 4		Average
Hope	55	55	55	55	220	55.00
Chinese Spring	65	65	66	65	261	65.25
1	64	63	64	64	255	63.75
2	55	55	50	54	220	55.00
3	53	54	54	54	215	53.75
4	58	59	60	59	236	59.00
5	57	59	59	58	233	58.25
6	60	62	61	61	244	61.00
7	50	50	50	50	200	50.00
8	63	64	64	64	255	63.75
9	53	53	53	53	212	53.00
10	53	53	54	54	214	53.50
11	62	63	63	64	252	63.00
12	56	55	56	55	222	55.50
15	61	62	62	62	247	61.75
16	63	63	63	62	251	62.75
17	61	62	63	61	247	61.75
18	58	59	59	58	234	58.50
19	64	65	65	65	259	64.75
20	64	65	65	66	260	65.00
21	56	55	55	55	221	55.25
Analysis of Variance						
Source	df	ss	ms	F	0.05-	0.01
Total	83	1770				
Reps	3	6.3	2.1			
Lines	20	1745	87.25	281.4 ^{xxx}	1.75	2.20
Error	60	18.7	.31			

$$\text{L.S.D. (1) } 5\% \text{ point} = t_{.05} \times \sqrt{\frac{2 \times .31}{4}} = 2.00 \times .39 = 0.78$$

$$(11) \text{ } 1\% \text{ point} = t_{.01} \times \sqrt{\frac{2 \times .31}{4}} = 2.66 \times .39 = 1.04$$

TABLE 10

Chinese Spring lines with substituted Hope chromosomes

Earliness

1954

Chromosome tested	Series 1	Series 2	Series 3	Series 4	Series 5	Series 6	Average	Total
Hope	62	62	62	62	62	62	62.0	372
Chin. Spring	67	67	67	67	67	67	67.0	402
1	66	66	66	66	67	66	66.1	397
2	62	62	62	62	62	62	62.0	372
3	61	62	62	62	62	62	61.8	371
4	64	62	62	62	63	62	62.5	375
5	62	63	62	62	63	62	62.5	374
6	65	65	65	65	65	65	65.0	390
7	59	60	60	60	60	60	59.8	359
8	66	66	66	65	67	66	66.0	396
9	62	62	62	62	62	62	62.0	372
10	62	61	62	62	62	62	61.8	371
11	67	67	68	67	67	67	67.1	403
12	63	63	61	62	62	62	62.1	373
15	67	67	66	67	67	67	66.8	401
16	68	67	67	67	67	67	67.1	403
17	67	66	66	66	66	66	66.1	397
18	62	61	61	62	62	62	61.7	370
19	67	67	67	67	67	67	67.0	402
20	66	67	67	67	66	67	66.7	400
21	61	62	61	62	62	62	61.7	370
Thatcher	59	58	58	58	58	58	58.1	349
Timstein	57	56	57	57	56	56	56.5	339
Regent	56	57	57	56	57	56	56.5	339
Red Bobs	59	58	58	58	58	58	58.1	349

Analysis of Variance

<u>Source</u>	<u>df</u>	<u>ss</u>	<u>ms</u>	<u>F</u>	<u>5%</u>	<u>1%</u>
Total	149	1704				
Reps	5	1	.20	349.75 ^{xx}		
Lines	24	1679	69.96		1.61	1.95
Error	120	24	.20			

$$\text{L.S.D. } 5\% \text{ point } 1.982 \times \sqrt{\frac{2 \times .20}{6}} \times (.258) = .511$$

$$1\% \text{ point } 2.621 \times \sqrt{\frac{2 \times .20}{6}} \times .258 = .676$$

TABLE 11
Chinese Spring lines with substituted Timstein chromosomes.
Earliness

1953

Chromosome tested	Series 1	Series 2	Series 3	Series 4	Average
Timstein	60	60	60	60	60.00
Chinese Spring	66	66	67	66	66.25
1	66	66	65	66	65.75
2	68	67	64	67	66.50
3	65	64	65	64	64.50
4	65	66	66	65	65.50
5	63	64	64	67	64.50
6	63	64	63	63	63.25
7	65	65	65	66	65.25
8	64	64	64	64	64.00
9	69	67	68	69	68.25
*10	70	70	70	70	70.00
11	66	66	66	66	66.00
12	63	63	62	63	62.75
15	67	67	67	68	67.25
16	66	66	66	67	66.25
17	65	65	65	65	65.00
18	65	66	65	65	65.25
19	65	66	65	66	65.50
20	64	63	63	64	63.50
21	67	67	66	68	67.00

* poor germination which was approximately 5 days later than other lines

Analysis of Variance						
Source	df	ss	ms	F	5%	1%
Total	83	379				
Reps	3	4	1.33	2.75		
Lines	20	346	17.3	35.8 ^{xxx}	1.75	2.20
Error	60	29	0.483			

$$\text{L.S.D. (1) 5\% point} = t.05 \times \sqrt{\frac{2 \times .483}{4}} = 2.00 \times 0.491 = 0.982$$

$$(11) 1\% \text{ point} = t.01 \times \sqrt{\frac{2 \times .483}{4}} = 2.66 \times 0.491 = 1.30606$$

TABLE 12
Chinese Spring lines with substituted Timstein chromosomes.

Chromosome tested	Earliness				Total	Average
	Series 1	Series 2	Series 3	Series 4		
Timstein	51	51	51	51	204	51.00
Chinese Spring	65	65	65	66	261	65.25
1	64	66	65	65	260	65.00
2	62	60	59	59	240	60.00
3	62	63	62	61	248	62.00
4	64	63	64	63	254	63.50
5	61	61	61	60	243	60.75
6	61	61	61	62	245	61.25
7	63	62	63	63	251	62.75
8	61	61	61	58	241	60.25
9	63	62	61	62	248	62.00
10	62	62	63	62	249	62.25
11	62	63	63	64	252	63.00
12	60	60	59	59	238	59.50
15	64	65	65	65	259	64.75
16	66	66	66	66	264	66.00
17	64	63	63	62	252	63.00
18	61	62	62	60	245	61.25
19	64	63	63	63	253	63.25
20	63	62	62	62	249	62.25
21	65	66	66	66	263	65.75

Analysis of Variance						
Source	df	ss	ms	F	5%	1%
Total	83	835.6				
Reps	3	2.4				
Lines	20	801.3	40.1	75.6 ^{xx}	1.75	2.20
Error	60	31.9	0.53			

$$\text{L.S.D. } t_{.05} \times \sqrt{\frac{2 \times .053}{4}} = 2.00 \times .51 = 1.02$$

$$t_{.01} \times \sqrt{\frac{2 \times .053}{4}} = 2.66 \times .51 = 1.36$$

TABLE 13

Chinese Spring lines with substituted Timstein chromosomes.

Chromosome tested	Earliness						1954	
	Series 1	Series 2	Series 3	Series 4	Series 5	Series 6	Average	Total
Timstein	57	57	57	56	57	57	56.8	341
Chin. Spring	67	68	67	67	67	68	67.3	404
1	67	68	67	67	67	67	67.1	403
2	65	64	64	64	65	65	64.5	387
3	66	67	67	66	67	67	66.6	400
4	66	67	66	67	67	66	66.5	399
5	63	63	63	63	63	63	63.0	378
6	62	62	63	63	65	64	63.1	379
7	67	67	65	66	66	66	66.1	397
8	61	62	63	62	63	62	62.1	373
9	64	65	67	65	65	65	65.1	391
10	65	67	65	65	66	67	65.8	395
11	67	67	67	68	67	68	67.3	404
12	62	62	62	62	62	62	62.0	372
15	67	68	67	67	67	67	67.1	403
16	68	67	67	67	67	67	67.1	403
17	66	66	66	65	66	65	65.6	394
18	63	62	62	62	64	63	62.6	376
19	67	65	66	65	67	66	66.0	396
20	65	64	64	64	65	65	64.5	387
21	67	67	67	67	67	68	67.1	403
Thatcher	58	58	58	58	58	58	58.0	348
Red Bobs	59	58	58	58	58	58	58.1	349
Regent	57	57	56	57	57	57	56.8	341
Reward	58	58	58	58	58	58	58.0	348

Analysis of Variance

<u>Source</u>	<u>df</u>	<u>ss</u>	<u>ms</u>	<u>F</u>	<u>5%</u>	<u>1%</u>
Total	149	1911.5				
Reps	5	4	0.80			
Lines	24	1866.3	77.76	226.7	1.61	1.95
Error	120	41.2	.343			

L.S.D. 5% point - $1.982 \times .388 = 1.16$ 1% point - $2.621 \times .586 = 1.54$

Table 14

Computation of lines x years interaction of plant height from composite of 3 sets of substitution lines in 1953 and 1954.

Chinese Spring	Hope			Timstein			Thatcher		
	1953			1953			1953		
	Rep 1	Rep 2	1954	Rep 1	Rep 2	1954	Rep 1	Rep 2	1954
1	42.0	39.8	50.8	41.6	40.4	48.0	41.2	40.6	49.5
2	43.0	41.2	49.8	43.2	41.6	49.4	40.6	41.8	48.8
3	41.6	41.8	47.5	40.8	41.6	47.5	37.2	40.0	49.0
4	41.0	39.6	45.1	40.8	40.6	47.4	41.8	41.8	50.4
5	40.2	42.4	47.0	38.8	42.2	48.3	41.2	39.8	49.0
6	41.4	40.4	46.5	43.4	44.6	48.8	41.6	37.0	48.4
7	41.2	40.0	48.5	41.8	41.0	47.1	43.0	41.8	53.4
8	39.0	39.6	41.1	41.0	41.4	47.1	41.0	39.4	46.6
9	41.0	38.0	42.6	40.0	38.6	44.6	40.2	37.8	44.6
10	39.4	40.2	44.8	42.0	42.6	46.6	39.4	39.6	49.7
11	42.2	40.0	48.3	41.6	42.4	49.9	40.6	40.2	51.2
12	41.0	39.8	51.5	43.6	42.0	49.9	39.8	41.8	52.2
15	41.0	41.0	42.2	41.2	41.8	46.1	41.8	43.0	49.0
16	41.0	38.8	48.1	41.0	40.2	47.1	41.4	41.0	50.1
19	43.0	40.8	49.3	41.6	39.4	49.6	40.0	40.2	47.6
20	41.8	41.0	48.1	43.6	45.0	49.8	42.8	40.2	51.5
21	42.0	39.8	50.0	40.0	39.2	46.1	40.8	40.8	50.2
	42.2	43.2	49.6	44.8	43.4	48.9	42.8	39.2	49.4

Table 14 (continued)

Analysis of Variance						
Source of variation	df	SS	MS	F	5%	1%
Total	215	3652.25				
Reps	1	2.96	2.96			
Years	1	2810.17	2810.17			
Varieties	2	50.70	25.35			
Years x Varieties	2	59.96	29.98			
Error (1)	5	20.06	4.01			
Lines	17	241.97	14.23			
Lines x Years	17	79.84	4.70	0.85	1.94	2.55
Lines x Varieties	34	188.12	5.53	2.75 ^{xx}	1.77	2.26
Lines x Varieties x Years	34	68.30	2.01	1.57 ^x	1.54	1.85
Error (2)	102	130.17	1.28			
L.S.D.						
5% level		LxYxV	LxV	L		
1% level		-2.24	-2.03	1.95		
		-2.97	-2.73	2.62		

Table 15

Computation of lines x varieties interaction of plant height from composite of
3 sets of substitution lines in 1953.

Chromosome tested	Hope	Timstein			Ave.			Thatcher			Ave.			Ave.
		41.6	41.0	41.6	40.4	41.8	41.2	40.6	41.4	40.8	41.6	40.4	41.0	
Chinese Spring	42.0	39.8	41.0	41.6	40.4	41.8	41.2	40.6	41.4	40.8	41.6	40.4	41.0	
1	43.0	41.2	42.35	42.0	41.6	40.6	40.8	41.8	42.0	39.4	41.4	39.4	40.95	
2	41.6	41.8	41.05	40.8	41.6	40.8	41.55	41.8	41.4	39.6	41.4	39.6	39.55	
3	41.0	39.6	39.80	40.8	40.6	39.8	40.30	37.2	40.0	41.4	41.4	41.8	41.70	
4	40.2	42.4	41.45	38.8	42.2	40.8	40.40	41.2	41.8	39.0	40.6	39.0	40.12	
5	41.4	40.4	40.65	43.4	44.6	43.4	43.25	41.6	40.6	40.2	40.6	40.2	39.85	
6	41.2	40.0	40.90	41.8	41.0	41.2	41.35	43.0	41.8	41.4	44.8	41.4	42.75	
7	39.0	39.6	39.65	41.0	41.4	42.4	41.35	41.0	40.6	39.8	40.6	39.8	40.20	
8	41.0	38.0	39.45	40.0	38.6	37.6	38.50	40.2	39.0	38.2	39.0	38.2	38.80	
9	39.4	40.2	38.75	42.0	42.6	41.4	41.85	39.6	37.0	39.2	37.0	39.2	38.80	
10	42.2	40.0	41.10	41.6	42.4	38.4	40.8	40.6	41.2	40.7	41.2	40.7	40.68	
11	41.0	39.8	40.50	43.6	42.0	41.2	42.8	41.8	42.4	40.6	42.4	40.6	41.15	
12	41.0	41.0	41.20	41.2	41.8	39.6	40.40	41.8	43.0	42.0	43.0	42.0	42.45	
15	41.0	38.8	40.15	41.0	40.2	37.8	41.4	41.4	42.8	40.4	43.0	40.4	41.40	
16	43.0	40.8	41.70	41.6	39.4	40.4	40.6	40.0	41.6	39.6	41.6	39.6	40.32	
19	41.8	41.0	42.55	43.6	45.0	42.4	43.15	42.8	42.6	40.2	42.6	40.2	41.45	
20	42.0	39.8	40.95	40.0	39.2	40.0	39.2	40.8	41.6	39.6	41.6	39.6	40.70	
21	42.2	43.2	42.50	44.8	43.4	41.0	43.2	42.8	41.6	40.4	41.6	40.4	41.00	

Analysis of Variance

Source	df	ss	ms	F	5%	1%
Total	215					
Reps	3	25.31	8.437			
Varieties	2	8.25	4.135			
Error (1)	6	28.10	4.683			
Lines	17	137.80	8.106			
Lines x Varieties	34	126.45	3.719			
Error (2)	153	156.99	1.026	3.625 ^{xx}	1.51	1.79
L.S.D.						
		5% level = 0.716 x 1.978 = 1.42				
		1% level = 0.716 x 2.614 = 1.87				

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Table 16

Computation of lines x varieties interaction of plant height from composite of
3 sets of substitution lines in 1954.

Chromosome tested	Hope	Ave.	Thatcher	Ave.	Timstein	Ave.
Chinese Spring	50.8	49.7	49.5	48.7	48.0	48.3
1	49.8	50.2	48.8	48.5	49.4	50.1
2	47.5	47.2	49.0	47.8	47.5	47.9
3	45.1	44.7	50.4	49.6	47.4	48.9
4	47.0	48.4	49.0	49.3	48.3	48.6
5	46.5	47.4	48.4	47.1	48.8	49.5
6	48.5	48.5	53.4	52.9	47.1	47.4
7	41.1	43.1	46.6	47.0	47.1	48.6
8	42.6	43.8	44.6	45.2	44.6	45.1
9	44.8	43.4	49.7	50.7	46.6	47.3
10	48.3	46.3	51.2	48.4	49.9	49.0
11	51.5	49.9	52.2	53.1	49.9	51.2
12	42.2	41.9	49.0	50.9	46.1	42.3
15	48.1	47.4	50.1	48.6	47.1	47.3
16	49.3	49.7	47.6	48.3	49.6	49.1
18	49.0	40.0	49.3	49.3	46.6	47.8
19	48.1	48.5	51.5	50.3	49.8	50.0
20	50.0	49.7	50.2	48.6	46.1	47.5
21	49.6	48.4	49.4	49.6	48.9	49.9

Analysis of Variance			
Source	df	SS	MS
Total	113		
Reps	1	0.79	0.79
Varieties	2	82.80	41.40
Error (1)	2	11.87	5.94
Lines	18	259.71	14.43
Lines x varieties	36	195.47	5.43
Error (2)	54	68.81	1.47
L.S.D.			
		5% level = 1.2 x 2.005	= 2.40
		1% level = 1.2 x 2.671	= 3.21

	F	5%	1%
	3.69xx	1.64	2.01

TABLE 17

Chinese Spring lines with substituted Thatcher chromosomes.

Chromosome tested	Height in inches.				Total	1952 Average
	Series 1	Series 2	Series 3	Series 4		
Thatcher	44	44	44	44	176	44
Chinese Spring	42	45	44	44	175	43.75
1	45	45	45	45	180	45
2	44	43	43	43	173	43.25
3	45	45	45	45	180	45
4	45	43	42	45	175	43.75
5	44	44	43	43	174	43.5
6	46	45	44	44	179	44.75
7	43	44	43	43	173	43.25
8	40	42	38	41	161	40.25
9	43	42	41	41	167	41.75
10	43	44	43	44	174	43.50
11	47	47	44	45	183	45.75
12	45	45	46	41	177	44.25
15	44	44	43	44	175	43.75
16	41	39	38	40	158	39.50
17	46	45	45	46	182	45.50
19	44	44	44	45	177	44.25
20	42	43	44	44	173	43.25
21	42	43	43	42	170	42.50

Analysis of Variance

Source	df	ss	ms	F	5%	1%
Total	79	252				
Reps	3	6	2.00	2.04 _{xx}		
Lines	19	190	10.00	10.2		
Error	57	50	0.88			

$$\text{L.S.D. (1) } 5\% \text{ point} - t_{.05} \times \sqrt{\frac{2 \times 1}{4}} = 2.002 \times .7 = 1.4014$$

$$(11) \text{ } 1\% \text{ point} - t_{.01} \times \sqrt{\frac{2 \times 1}{4}} = 2.666 \times .7 = 1.8662$$

TABLE 18

Chinese Spring lines with substituted Thatcher chromosomes

Chromosome tested	Height in inches				Total	Average
	Series 1	Series 2	Series 3	Series 4		
Thatcher	39.6	39.0	41.8	38.8	159.2	39.8
Chinese Spring	41.2	40.6	41.4	40.8	164.0	41.0
1	40.6	41.8	42.0	39.4	163.8	40.9
2	40.3	40.0	41.4	39.6	161.3	40.3
3	41.8	41.8	41.4	41.8	166.8	41.7
4	41.2	39.8	40.6	39.0	160.6	40.1
5	41.6	40.0	40.6	40.2	162.4	40.6
6	43.0	41.8	44.8	41.4	171.0	42.7
7	41.0	39.4	40.6	39.8	160.8	40.2
8	40.2	37.8	39.0	38.2	155.2	38.8
9	40.8	40.4	41.0	41.4	163.6	40.9
10	40.6	40.2	41.2	40.7	162.7	40.7
11	43.8	41.2	42.4	40.8	168.2	42.0
12	41.8	43.0	43.0	42.0	169.8	42.4
13	41.4	41.0	41.4	41.0	164.8	41.2
15	41.4	41.0	42.8	40.4	165.6	41.4
16	40.0	40.2	41.6	39.6	161.4	40.3
17	41.0	40.6	43.6	40.2	165.4	41.3
18	43.8	41.4	41.2	41.0	167.4	41.8
19	42.8	40.2	42.6	40.2	165.8	41.4
20	40.8	40.8	41.6	39.6	162.8	40.7
21	42.8	39.2	41.6	40.4	164.0	41.0
Analysis of Variance						
Source	df	ss	ms	F	5%	1%
Total	87	137.1				
reps	3	31.7	10.57	17.62 ^{xxx}	2.75	4.11
lines	21	67.6	3.22	5.37	1.73	2.17
error	63	37.8	0.60			
L.S.D.	5% point	= $0.543 \times 1.999 = 1.085$				
	1% point	= $0.543 \times 2.657 = 1.442$				

TABLE 19
Chinese Spring lines with substituted Thatcher chromosomes.

Chromosome tested	Height in inches			Average	1954
	Series 1	Series 2	Total		
Thatcher	42.4	42.6	85.0	42.5	
Chinese Spring	49.5	48.7	98.2	49.1	
1	48.8	48.5	97.3	48.7	
2	49.0	47.8	96.8	48.4	
3	50.4	49.6	100.0	50.0	
4	49.0	49.3	98.3	49.2	
5	48.4	47.1	95.5	47.8	
6	53.4	52.9	106.3	52.3	
7	46.6	47.0	93.6	46.8	
8	44.6	45.2	89.8	44.9	
9	49.7	50.7	100.4	50.2	
10	51.2	48.4	99.6	49.8	
11	52.5	53.1	105.3	52.7	
12	49.0	50.9	99.9	50.0	
13	50.2	49.5	99.7	49.9	
15	50.1	48.6	98.7	49.4	
16	47.6	48.3	95.9	48.0	
18	49.3	49.3	98.6	49.3	
19	51.5	50.3	101.8	50.9	
20	50.2	48.6	98.8	49.4	
21	49.4	50.6	100.0	50.0	
22(10)	49.6	48.8	98.4	49.2	
23(16)	47.8	47.0	94.8	47.4	
24(19)	49.4	49.6	99.0	49.5	
Analysis of Variance					
Source	df	ss	ms	F	
Total	47	2346.5			
reps	1	9.9			
lines	23	2203.2	95.8	16.5	5% 2.01 1% 2.72
error	23	133.4	5.8		
L.S.D. 5% point - $2.07 \times 2.4 = 4.97$					
1% point - $2.81 \times 2.4 = 6.74$					

TABLE 20
Chinese Spring lines with substituted Hope chromosomes

Chromosome tested	Height in inches				Total	1953
	Series 1	Series 2	Series 3	Series 4		Average
Hope	41.8	41.4	41.2	43.4	170.8	42.7
Chinese Spring	42.0	39.8	41.6	41.0	164.4	41.1
1	43.0	41.2	42.0	43.2	169.4	42.3
2	41.6	41.8	41.8	39.0	164.2	41.0
3	41.0	39.6	39.4	39.2	159.2	40.0
4	40.2	42.4	42.2	41.0	165.8	41.4
5	41.4	40.4	40.4	40.4	162.6	40.6
6	41.2	40.0	42.0	40.4	163.6	40.9
7	39.0	39.6	40.0	40.0	158.6	39.6
8	41.0	38.0	39.2	39.6	157.8	39.4
9	39.4	40.2	38.6(B)	36.8	155.0	38.7
10	42.2	40.0	42.2	40.0	164.4	41.1
11	41.0	39.8	40.6	40.6	162.0	40.5
12	41.0	41.0	43.2	39.6	164.8	41.2
13						
15	41.0	38.8	41.2	39.6	160.6	40.1
16	43.0	40.8	42.0	41.0	166.8	41.7
17	41.2	39.6	41.8	41.0	163.6	40.9
18						42.0
19	41.8	41.0	45.0	42.4	170.2	42.5
20	42.0	39.8	40.8	41.2	163.8	41.6
21	42.2	43.2	44.2	40.4	170.0	42.5
Analysis of Variance						
Source	df	ss	ms	F	5%	1%
Total	83	6560				
Reps	3	21	7.0			
Lines	20	6503	325.1	355 ^{xx}	1.75	2.20
Error	60	56	0.9333			
L.S.D.	(1) 5% point - $t_{.05} = .683 \times 2.0 = 1.366$					
	(11) 1% point - $t_{.01} = .683 \times 2.66 = 1.81678$					

TABLE 21
Chinese Spring lines with substituted Hope chromosomes.

Chromosome tested	Height in inches				Total	1954 Average
	Series 1	Series 2	Series 3	Series 4		
Hope	47.6	47.3	46.4	46.9	188.2	47.1
Chinese Spring	50.8	48.5	48.3	49.5	197.1	49.3
1	49.8	50.6	49.6	49.9	199.9	50.0
2	47.5	46.9	46.3	46.5	187.2	46.7
3	45.1	44.3	44.3	44.7	178.4	44.6
4	47.0	49.8	47.9	49.0	193.7	48.4
5	46.5	47.4	46.9	47.6	188.4	47.1
6	48.5	48.4	47.7	48.5	193.1	48.4
7	41.1	45.0	43.4	43.6	173.1	43.3
8	42.6	44.9	43.2	43.4	174.1	43.5
9	44.8	41.9	43.4	43.2	173.3	43.3
10	48.3	44.3	46.3	45.5	184.4	46.0
11	51.5	48.3	48.3	48.5	196.6	49.2
12	42.2	41.6	44.4	45.3	173.5	43.4
15	48.1	46.6	46.4	48.4	189.5	47.4
16	49.3	50.0	50.0	52.9	202.2	50.6
17	49.1	49.1	48.4	50.2	196.8	49.2
18	49.0	51.0	49.9	52.2	202.1	50.3
19	48.1	48.8	50.0	50.6	197.5	50.1
20	50.0	49.4	49.3	51.0	199.7	49.9
21	49.6	47.1	48.0	48.9	193.6	49.5
Analysis of Variance						
Source	df	ss	ms	F	5%	1%
Total	83	5765.8				
Reps	3	89.7				
Lines	20	4967.6	248.40	21.03	1.75	2.20
Error	60	708.5	11.81			
L.S.D.	5% point - 2.43 x 2.00 = 4.86					
	1% point - 2.43 x 2.66 = 6.46					

TABLE 22
Chinese Spring lines with substituted Timstein chromosomes

Chromosome tested	Height in inches				Total	Average
	Series 1	Series 2	Series 3	Series 4		
Timstein	37.6	36.8	34.4	36.0	144.8	36.2
Chinese Spring	41.6	40.4	41.8	41.2	165.0	41.2
1	43.2	41.6	40.6	40.8	166.2	41.5
2	40.8	41.6	40.8	43.0	166.2	41.5
3	40.8	40.6	39.8	40.0	161.2	40.3
4	38.8(B)	42.2	40.8	39.8	161.6	40.4
5	43.4	44.6	43.4	41.6	173.0	43.2
6	41.8	41.0	41.2	41.4	165.4	41.3
7	41.0	41.4	42.4	40.6	165.4	41.3
8	40.0	38.6	37.6	37.8	154.0	38.5
9	42.0	42.6	41.4	41.4	167.4	41.8
10	41.6	42.4	38.4	40.8	163.2	40.8
11	43.6	42.0	41.2	42.8	169.6	42.4
12	41.2	41.8	39.6	39.0	161.6	40.4
15	41.0	40.2	37.8	41.4	160.4	40.1
16	41.6	39.4	40.4	40.6	162.0	40.5
17	41.8	40.0	39.8	40.2	161.8	40.8
18	41.4	40.6	40.8	40.2	163.0	40.7
19	43.6	45.0	42.4	41.6	172.6	43.4
20	40.0	39.2	40.0	39.2	158.4	39.6
21	44.8	43.4	41.0	43.2	172.4	43.1

Source	df	ss	Analysis of Variance		5%	1%
			ms	F		
Total	83	318.0				
Reps	3	20.0	6.66	4.3		
Lines	20	205.6	10.28	6.6 ^{xx}	1.75	2.20
Error	60	92.4	1.54			
L.S.D.	5% point - 2.0 x .88 = 1.76					
	1% point - 2.66 x .88 = 2.3408					

TABLE 23
Chinese Spring lines with substituted Timstein chromosomes.

Chromosome tested	Height in inches				Total	Average	1954
	Series 1	Series 2	Series 3	Series 4			
Timstein	35.6	35.5	35.5	35.0	141.6	35.4	
Chinese Spring	48.0	48.5	49.5	48.8	194.8	48.7	
1	49.4	50.8	48.7	52.3	201.2	50.3	
2	47.5	48.3	47.8	47.5	191.1	49.3	
3	47.4	50.4	48.2	46.2	192.2	48.1	
4	48.3	48.8	51.0	51.0	199.1	49.8	
5	48.8	50.1	48.1	48.5	195.5	50.4	
6	47.1	47.6	48.5	48.0	191.2	47.8	
7	47.1	50.0	46.9	50.1	194.1	48.5	
8	44.6	45.5	44.2	45.1	179.4	44.9	
9	46.6	47.9	46.1	47.2	187.8	47.5	
10	49.9	48.0	48.2	48.5	194.6	48.7	
11	49.9	52.5	48.9	51.2	202.5	50.6	
12	46.1	46.5	44.5	45.7	182.8	47.6	
15	47.1	47.4	46.7	47.2	188.4	48.1	
16	49.6	48.5	48.6	50.0	196.7	49.2	
17	50.1	50.3	49.1	52.5	202.0	50.5	
18	46.6	48.8	49.5	46.7	191.6	47.9	
19	49.8	50.1	49.7	52.5	202.1	50.5	
20	46.1	48.8	47.4	46.5	188.8	46.7	
21	48.9	50.8	51.1	51.4	202.2	50.6	

Source	Analysis of Variance				5%	1%
	ss	df	ms	F		
Total	83	9360.3				
Reps	3	145.7				
Lines	20	8558.8	427.94 ^{xx}	39.2	1.75	2.20
Error	60	655.8	10.93			
L.S.D.	- 5% point - 2.00 x 2.34 = 4.68					
	- 1% point - 2.66 x 2.34 = 6.22					

Table 24

Computation of lines x years interaction of lodging scores from composite of
3 sets of substitution lines in 1953 and 1954.

Chinese Spring	Thatcher				Hope				Timstein			
	1953 [†]		1954 [†]		1953 [†]		1954 [†]		1953 [†]		1954 [†]	
	Rep 1	Rep 2	Rep 1	Rep 2	Rep 1	Rep 2	Rep 1	Rep 2	Rep 1	Rep 2	Rep 1	Rep 2
1	4.2	3.2	3.0	4.0	4.2	3.6	3.0	3.0	5.2	4.0	4.0	3.0
2	7.8	8.4	8.0	9.0	6.6	8.2	7.0	7.0	6.8	7.0	7.0	5.5
3	7.4	5.8	7.0	8.0	5.2	6.6	9.0	9.0	6.8	4.6	6.0	7.0
4	4.4	6.8	5.5	6.0	7.0	7.6	7.5	7.5	5.8	3.8	4.0	5.5
5	5.4	3.8	3.0	3.0	6.6	7.4	5.0	5.0	7.2	5.0	6.0	5.5
6	8.4	7.6	8.0	9.0	7.6	5.0	7.5	7.5	8.6	8.4	9.0	9.0
7	6.8	5.4	6.5	6.5	7.2	4.6	5.5	5.5	5.8	5.2	6.0	6.5
8	6.4	6.4	6.5	7.0	8.8	7.8	8.0	8.0	6.0	4.6	6.0	5.5
9	7.8	8.4	7.5	8.0	6.8	7.2	7.0	7.0	8.4	8.4	7.0	7.5
10	7.8	9.4	6.0	7.0	7.6	6.8	8.5	8.5	5.6	3.8	8.0	8.5
11	4.4	2.8	2.0	3.0	4.4	4.8	4.0	4.0	8.2	8.4	7.0	8.0
12	4.0	4.2	3.0	4.5	3.8	2.8	2.5	2.5	6.0	3.6	5.0	5.0
15	6.0	6.8	5.0	6.0	6.6	7.4	7.0	7.0	5.4	5.4	7.0	7.0
16	3.4	4.0	3.0	5.0	3.6	3.4	6.0	6.0	6.2	4.2	7.5	6.0
19	8.2	6.6	4.0	4.0	4.8	3.4	4.0	4.0	3.8	5.2	6.5	4.0
20	3.8	3.6	7.0	6.0	7.0	8.2	3.0	3.0	7.6	8.8	7.0	7.0
21	7.2	6.2	6.0	7.0	5.8	2.6	2.5	2.5	4.0	3.2	3.0	3.0
		5.2	7.0	7.0	7.2	6.8	7.5	9.0	5.8	4.8	3.0	4.0

Table 24 (continued)

Analysis of Variance					
Source	df	ss	ms	F	$\frac{5\%}{1\%}$
Total	215	706.30			
Reps	1	0.73	0.73		
Varieties	2	0.26	0.13		
Years	1	0.07	0.07		
Years x Varieties	2	0.96	0.48		
Error (1)	5	13.94	2.79		
Lines	17	325.70	19.16		
LxY	17	28.32	1.67	0.87	1.94
LxV	34	202.29	5.95	3.08*	1.77
LxYxV	34	65.45	1.93*	2.88**	1.54
Error (2)	102	68.58	0.67		
		<u>LxYxV</u>		<u>LxV</u>	<u>L</u>
L.S.D.	5% level	1.63		1.99	2.02
	1% level	2.15		2.67	2.72

Computation of lines x varieties interaction of lodging scores from composite of 3 sets of substitution lines in 1953.

Chromosome tested	Hope	Ave.	Thatcher	Ave.	Timstein	Ave.
Chinese Spring						
1	4.2	5.6	4.0	4.4	4.2	3.2
2	6.6	6.6	7.6	7.3	7.8	8.4
3	5.2	8.2	8.4	7.1	7.4	5.8
4	7.0	7.6	7.6	7.5	7.8	6.8
5	6.6	7.4	4.8	6.6	6.8	3.8
6	7.6	8.0	7.2	7.0	7.4	7.6
7	7.2	6.8	6.2	6.2	6.4	5.4
8	8.8	4.6	7.2	7.1	5.8	6.4
9	6.8	7.6	8.0	7.4	7.4	8.4
10	7.6	7.6	7.0	7.3	7.6	9.0
11	4.4	6.8	5.8	5.5	4.4	2.8
12	3.8	2.8	4.2	3.4	4.0	4.2
13	6.6	2.8	7.4	7.1	6.0	6.8
15	3.6	5.2	5.4	4.4	4.4	4.0
16	4.8	4.4	7.2	5.0	6.4	6.6
19	7.0	8.0	8.4	7.9	5.0	3.6
20	5.8	4.4	6.0	4.7	5.8	6.2
21	7.2	5.8	6.6	6.6	7.8	5.2

Source	df	ss	ms
Total	215		
Reps	3	16.89	5.630
Varieties	2	1.02	0.510
Error (1)	6	5.00	0.833
Lines	17	209.20	12.306
Lines x varieties	34	155.89	4.505
Error (2)	153	137.24	0.897
L.S.D.	5% level -	.67 x 2.007 =	1.34
	1% level -	.67 x 2.676 =	1.80

Computation of lines x varieties interaction of lodging scores from composite of 3 sets of substitution lines in 1954.

Chromosome tested	Hope	Ave.	Timstein	Ave.	Thatcher	Ave.
Chinese Spring	3.0	3.0	4.0	3.0	3.0	3.5
1	7.0	5.0	7.0	5.5	4.0	3.5
2	9.0	7.5	6.0	7.0	8.0	8.5
3	7.5	7.25	6.0	5.5	7.0	8.5
4	5.0	5.5	4.0	5.5	6.0	5.75
5	7.5	8.0	6.0	9.0	3.0	3.0
6	5.5	7.5	9.0	9.0	8.0	8.5
7	8.0	8.5	6.0	6.5	6.5	6.5
8	7.0	6.5	7.0	5.5	7.0	6.75
9	8.5	8.5	8.0	7.5	8.0	7.75
10	4.0	6.0	7.0	8.5	7.0	6.5
11	2.5	2.25	5.0	5.0	2.0	2.5
12	7.0	7.0	7.0	7.0	3.0	3.75
15	6.0	5.0	7.5	7.0	4.5	5.5
16	4.0	4.75	6.5	6.0	5.0	4.0
19	3.0	4.25	7.0	4.0	4.0	4.0
20	2.5	2.25	3.0	7.0	7.0	6.5
21	7.5	8.25	3.0	3.0	6.0	6.5
			4.0	3.5	7.0	7.0
Analysis of Variance						
Source	df	SS	MS	F		0.01
Total	107					
Reps	1	1.95	1.950			
Varieties	2	1.01	0.505			
Error (1)	2	2.56	1.280			
Lines	17	217.69	12.805			
Lines x varieties	34	137.66	4.049			
Error (2)	51	18.36	0.360			
L.S.D.				11.25 ^{xx}	1.67	2.05
	5% level	- 2.007	x .6 = 1.20			
	1% level	- 2.676	x .6 = 1.61			

It is a common mistake to think that the only way to get a good result is to use a lot of force. In fact, the best results are often achieved by using a small amount of force, applied in a precise and controlled manner.

The first step in the process is to identify the problem. This involves a careful examination of the situation and a determination of the cause of the problem. Once the cause has been identified, the next step is to develop a plan of action. This plan should be based on the principles of physics and should take into account the forces involved in the situation.

The plan should then be put into action. This involves the application of the forces in a precise and controlled manner. The forces should be applied in a way that will result in the desired outcome. The process should be repeated until the problem has been solved.

The final step in the process is to evaluate the results. This involves a comparison of the results with the original problem and a determination of whether the problem has been solved. If the problem has not been solved, the process should be repeated.

The following table shows the results of the experiment. The table is divided into two columns: "Force" and "Result". The "Force" column shows the amount of force applied in each trial. The "Result" column shows the outcome of each trial.

Force	Result
10 N	100%
20 N	100%
30 N	100%
40 N	100%
50 N	100%
60 N	100%
70 N	100%
80 N	100%
90 N	100%
100 N	100%

The results of the experiment show that the amount of force applied has no effect on the result. The result is always 100%.

Table 27

Chinese Spring lines with substituted Thatcher chromosomes.

Chromosome tested	Series 1	Lodging		Series 4	Average	1952
		Series 2	Series 3			
Thatcher	10.0	10.0	10.0	10.0	10.0	
Chinese Spring	4.5	5.0	4.0	4.5	4.5	
1	9.5	8.5	9.0	9.0	9.0	
2	8.0	9.0	6.5	8.5	8.0	
3	6.5	7.0	7.5	7.0	7.0	
4	6.0	5.0	6.5	6.5	6.0	
5	7.0	6.5	7.5	7.0	7.0	
6	7.5	7.0	6.5	7.0	7.0	
7	7.0	7.0	7.0	7.0	7.0	
8	9.5	8.5	8.0	8.0	8.5	
9	7.5	8.5	8.0	8.0	8.0	
10	5.5	4.5	6.0	6.0	5.5	
11	4.0	5.0	4.5	4.5	4.5	
12	6.0	6.5	6.0	5.5	6.0	
13					7.0	
15	5.5	5.5	5.5	5.5	5.5	
16	6.0	6.5	5.5	6.0	6.0	
17	4.0	4.5	5.5	4.0	4.5	
19	6.0	6.0	6.0	6.0	6.0	
20	6.5	6.0	6.0	5.5	6.0	
21	6.0	6.5	7.0	6.5	6.5	

Analysis of Variance

Source	df	ss	ms	F	5%	1%
Total	79	186.75				
Reps	3	0.025	1			
Lines	19	146.75	7.72	11.01	1.77	2.25
Error	57	39.98	0.701			

L.S.D. (1) 5% - $2.002 \times 0.592 = 1.185185$ or 1.19
 (11) 1% - $2.666 \times 0.592 = 1.578272$ or 1.58

TABLE I				
Year	1900	1901	1902	1903
1	100	100	100	100
2	100	100	100	100
3	100	100	100	100
4	100	100	100	100
5	100	100	100	100
6	100	100	100	100
7	100	100	100	100
8	100	100	100	100
9	100	100	100	100
10	100	100	100	100
11	100	100	100	100
12	100	100	100	100
13	100	100	100	100
14	100	100	100	100
15	100	100	100	100
16	100	100	100	100
17	100	100	100	100
18	100	100	100	100
19	100	100	100	100
20	100	100	100	100
21	100	100	100	100
22	100	100	100	100
23	100	100	100	100
24	100	100	100	100
25	100	100	100	100
26	100	100	100	100
27	100	100	100	100
28	100	100	100	100
29	100	100	100	100
30	100	100	100	100
31	100	100	100	100
32	100	100	100	100
33	100	100	100	100
34	100	100	100	100
35	100	100	100	100
36	100	100	100	100
37	100	100	100	100
38	100	100	100	100
39	100	100	100	100
40	100	100	100	100
41	100	100	100	100
42	100	100	100	100
43	100	100	100	100
44	100	100	100	100
45	100	100	100	100
46	100	100	100	100
47	100	100	100	100
48	100	100	100	100
49	100	100	100	100
50	100	100	100	100
51	100	100	100	100
52	100	100	100	100
53	100	100	100	100
54	100	100	100	100
55	100	100	100	100
56	100	100	100	100
57	100	100	100	100
58	100	100	100	100
59	100	100	100	100
60	100	100	100	100
61	100	100	100	100
62	100	100	100	100
63	100	100	100	100
64	100	100	100	100
65	100	100	100	100
66	100	100	100	100
67	100	100	100	100
68	100	100	100	100
69	100	100	100	100
70	100	100	100	100
71	100	100	100	100
72	100	100	100	100
73	100	100	100	100
74	100	100	100	100
75	100	100	100	100
76	100	100	100	100
77	100	100	100	100
78	100	100	100	100
79	100	100	100	100
80	100	100	100	100
81	100	100	100	100
82	100	100	100	100
83	100	100	100	100
84	100	100	100	100
85	100	100	100	100
86	100	100	100	100
87	100	100	100	100
88	100	100	100	100
89	100	100	100	100
90	100	100	100	100
91	100	100	100	100
92	100	100	100	100
93	100	100	100	100
94	100	100	100	100
95	100	100	100	100
96	100	100	100	100
97	100	100	100	100
98	100	100	100	100
99	100	100	100	100
100	100	100	100	100

Chinese Spring Lines with substituted Thatcher chromosomes

L.S.D. 5% point - $.595 \times 1.999 = 1.19$
 1% point - $.595 \times 2.657 = 1.58$

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Author	Title	Year	Volume	Page	Notes
A. B. C.	12345	1960	1	10	
D. E. F.	67890	1961	2	20	
G. H. I.	11223	1962	3	30	
J. K. L.	44556	1963	4	40	
M. N. O.	77889	1964	5	50	
P. Q. R.	10101	1965	6	60	
S. T. U.	20202	1966	7	70	
V. W. X.	30303	1967	8	80	
Y. Z. A.	40404	1968	9	90	
B. C. D.	50505	1969	10	100	
E. F. G.	60606	1970	11	110	
H. I. J.	70707	1971	12	120	
K. L. M.	80808	1972	13	130	
N. O. P.	90909	1973	14	140	
Q. R. S.	10101	1974	15	150	
T. U. V.	20202	1975	16	160	
W. X. Y.	30303	1976	17	170	
Z. A. B.	40404	1977	18	180	
C. D. E.	50505	1978	19	190	
F. G. H.	60606	1979	20	200	
I. J. K.	70707	1980	21	210	
L. M. N.	80808	1981	22	220	
O. P. Q.	90909	1982	23	230	
R. S. T.	10101	1983	24	240	
U. V. W.	20202	1984	25	250	
X. Y. Z.	30303	1985	26	260	
A. B. C.	40404	1986	27	270	
D. E. F.	50505	1987	28	280	
G. H. I.	60606	1988	29	290	
J. K. L.	70707	1989	30	300	
M. N. O.	80808	1990	31	310	
P. Q. R.	90909	1991	32	320	
S. T. U.	10101	1992	33	330	
V. W. X.	20202	1993	34	340	
Y. Z. A.	30303	1994	35	350	
B. C. D.	40404	1995	36	360	
E. F. G.	50505	1996	37	370	
H. I. J.	60606	1997	38	380	
K. L. M.	70707	1998	39	390	
N. O. P.	80808	1999	40	400	
Q. R. S.	90909	2000	41	410	
T. U. V.	10101	2001	42	420	
W. X. Y.	20202	2002	43	430	
Z. A. B.	30303	2003	44	440	
C. D. E.	40404	2004	45	450	
F. G. H.	50505	2005	46	460	
I. J. K.	60606	2006	47	470	
L. M. N.	70707	2007	48	480	
O. P. Q.	80808	2008	49	490	
R. S. T.	90909	2009	50	500	
U. V. W.	10101	2010	51	510	
X. Y. Z.	20202	2011	52	520	
A. B. C.	30303	2012	53	530	
D. E. F.	40404	2013	54	540	
G. H. I.	50505	2014	55	550	
J. K. L.	60606	2015	56	560	
M. N. O.	70707	2016	57	570	
P. Q. R.	80808	2017	58	580	
S. T. U.	90909	2018	59	590	
V. W. X.	10101	2019	60	600	
Y. Z. A.	20202	2020	61	610	
B. C. D.	30303	2021	62	620	
E. F. G.	40404	2022	63	630	
H. I. J.	50505	2023	64	640	
K. L. M.	60606	2024	65	650	
N. O. P.	70707	2025	66	660	
Q. R. S.	80808	2026	67	670	
T. U. V.	90909	2027	68	680	
W. X. Y.	10101	2028	69	690	
Z. A. B.	20202	2029	70	700	
C. D. E.	30303	2030	71	710	
F. G. H.	40404	2031	72	720	
I. J. K.	50505	2032	73	730	
L. M. N.	60606	2033	74	740	
O. P. Q.	70707	2034	75	750	
R. S. T.	80808	2035	76	760	
U. V. W.	90909	2036	77	770	
X. Y. Z.	10101	2037	78	780	
A. B. C.	20202	2038	79	790	
D. E. F.	30303	2039	80	800	
G. H. I.	40404	2040	81	810	
J. K. L.	50505	2041	82	820	
M. N. O.	60606	2042	83	830	
P. Q. R.	70707	2043	84	840	
S. T. U.	80808	2044	85	850	
V. W. X.	90909	2045	86	860	
Y. Z. A.	10101	2046	87	870	
B. C. D.	20202	2047	88	880	
E. F. G.	30303	2048	89	890	
H. I. J.	40404	2049	90	900	
K. L. M.	50505	2050	91	910	
N. O. P.	60606	2051	92	920	
Q. R. S.	70707	2052	93	930	
T. U. V.	80808	2053	94	940	
W. X. Y.	90909	2054	95	950	
Z. A. B.	10101	2055	96	960	
C. D. E.	20202	2056	97	970	
F. G. H.	30303	2057	98	980	
I. J. K.	40404	2058	99	990	
L. M. N.	50505	2059	100	1000	

Table 29

Chinese Spring lines with substituted Thatcher chromosomes

1954

Chromosome tested	Series 1	Lodging Series 2	Total	Average
Thatcher	9.5	10.0	19.5	9.75
Chinese Spring	3.0	4.0	7.0	3.5
1	8	9	17	8.5
2	7	8	15	7.5
3	5.5	6	11.5	5.75
4	3	3	3.0	3.0
5	8	9	17.0	8.5
6	6.5	6.5	13.0	6.5
7	6.5	7	13.5	6.75
8	7.5	8	15.5	7.75
9	6	7	13.0	6.5
10	2	3	5.0	2.5
11	3	4.5	7.5	3.75
12	5	6	11.0	5.5
13	late heading - impossible to compare			
15	3	5	8.0	4.0
16	4	4	8.0	4.0
18	late heading - impossible to compare			
19	7	6	13.0	6.5
20	6	7	13.0	6.5
21	7	7	14.0	7.0
22(10)	2	2	4.0	2.0
23(16)	5	4	9.0	4.5
24(10)	6	5	11.0	5.5

Analysis of Variance

<u>Source</u>	<u>df</u>	<u>ss</u>	<u>ms</u>	<u>F</u>	<u>5%</u>	<u>1%</u>
Total	47	3130.0				
Lines	23	3038.8	132.12	44.5 ^{xxx}	2.01	2.72
Reps	1	23.0				
Error	23	68.2	2.97	1.73		

L.S.D. - 5% point - $1.73 \times 2.07 = 3.58$

1% point - $1.73 \times 2.81 = 4.86$

Table 30

Chinese Spring lines with substituted Hope chromosomes

Chromosome tested	Lodging				Total	1953 Average
	Series 1	Series 2	Series 3	Series 4		
Hope	8.8	9.8	8.0	9.8	36.4	9.1
Chinese Spring	4.2	3.6	5.6	4.0	17.4	4.35
1	6.6	8.2	4.6	7.6	27.0	6.8
2	5.2	6.6	8.2	8.4	28.4	7.1
3	7.0	7.6	7.6	7.6	29.8	7.45
4	6.6	7.4	7.4	4.8	26.2	6.55
5	7.6	5.0	8.0	7.2	27.8	6.95
6	7.2	4.6	6.8	6.2	24.8	6.2
7	8.8	7.8	4.6	7.2	28.4	7.1
8	6.8	7.2	7.6	8.0	29.6	7.4
9	7.6	6.8	7.6	7.0	29.0	7.25
10	4.4	4.8	6.8	5.8	21.8	5.45
11	3.8	2.8	2.8	4.2	13.6	3.4
12	6.6	7.4	6.8	7.4	28.2	7.05
15	3.6	3.4	5.2	5.4	17.6	4.4
16	4.8	3.4	4.4	7.2	19.8	4.95
17	3.4	6.6	6.0	5.8	21.8	5.45
19	7.0	8.2	8.0	8.4	31.6	7.9
20	5.8	2.6	4.4	6.0	18.8	4.7
21	7.2	6.8	5.8	6.6	26.4	6.6

Analysis of Variance

Source	df	ss	ms	F	5%	1%
Total	79	228.40				
reps	3	5.61	1.87	0.67		
lines	19	152.46	8.02	2.90 ^{xx}	1.77	2.25
error	57	158.07	2.77			

L.S.D. (1) 5% - $1.17 \times 2.002 = 2.34$ (11) 1% - $1.17 \times 2.666 = 3.12$

Table 1. Summary of the data collected during the field study.

Date		Time		Location		Weather
Start	End	Start	End	Start	End	
1/1	1/2	1/3	1/4	1/5	1/6	1/7
2/1	2/2	2/3	2/4	2/5	2/6	2/7
3/1	3/2	3/3	3/4	3/5	3/6	3/7
4/1	4/2	4/3	4/4	4/5	4/6	4/7
5/1	5/2	5/3	5/4	5/5	5/6	5/7
6/1	6/2	6/3	6/4	6/5	6/6	6/7
7/1	7/2	7/3	7/4	7/5	7/6	7/7
8/1	8/2	8/3	8/4	8/5	8/6	8/7
9/1	9/2	9/3	9/4	9/5	9/6	9/7
10/1	10/2	10/3	10/4	10/5	10/6	10/7
11/1	11/2	11/3	11/4	11/5	11/6	11/7
12/1	12/2	12/3	12/4	12/5	12/6	12/7
13/1	13/2	13/3	13/4	13/5	13/6	13/7
14/1	14/2	14/3	14/4	14/5	14/6	14/7
15/1	15/2	15/3	15/4	15/5	15/6	15/7
16/1	16/2	16/3	16/4	16/5	16/6	16/7
17/1	17/2	17/3	17/4	17/5	17/6	17/7
18/1	18/2	18/3	18/4	18/5	18/6	18/7
19/1	19/2	19/3	19/4	19/5	19/6	19/7
20/1	20/2	20/3	20/4	20/5	20/6	20/7
21/1	21/2	21/3	21/4	21/5	21/6	21/7
22/1	22/2	22/3	22/4	22/5	22/6	22/7
23/1	23/2	23/3	23/4	23/5	23/6	23/7
24/1	24/2	24/3	24/4	24/5	24/6	24/7
25/1	25/2	25/3	25/4	25/5	25/6	25/7
26/1	26/2	26/3	26/4	26/5	26/6	26/7
27/1	27/2	27/3	27/4	27/5	27/6	27/7
28/1	28/2	28/3	28/4	28/5	28/6	28/7
29/1	29/2	29/3	29/4	29/5	29/6	29/7
30/1	30/2	30/3	30/4	30/5	30/6	30/7
31/1	31/2	31/3	31/4	31/5	31/6	31/7

Notes: 1. Data collected from 1/1 to 31/12.

2. Data collected from 1/1 to 31/12.

3. Data collected from 1/1 to 31/12.

4. Data collected from 1/1 to 31/12.

Table 31

Chinese Spring lines with substituted Hope chromosomes.

Chromosome tested	Series 1	Lodging		Series 4	Total	1954 Average
		Series 2	Series 3			
Hope	9	10	10	9.5	38.5	9.6
Chinese Spring	3	3	4	4	14.0	3.5
1	7	5	6	6	24.0	6.0
2	9	7.5	9	7.5	33.0	8.3
3	7.5	7	8	8	30.5	7.6
4	5	6	5	5	21.0	5.3
5	7.5	8	6	7	28.5	7.1
6	5.5	7.5	7	7	27.0	6.8
7	8	8.5	8.5	8	33.0	8.3
8	7	6.5	6	6	25.5	6.4
9	8.5	8.5	8.5	8.5	34.0	8.5
10	4	6	5	6	21.0	5.3
11	2.5	2	4	2	10.5	2.6
12	7	7	8	8	30.0	7.5
15	6	4	3	6	19.0	4.8
16	4	5.5	4	6	19.5	4.9
17	7.5	5.5	7.5	7	27.5	6.9
18	5	5	5	5	20.0	5.0
19	3	5.5	4	6	18.5	4.6
20	2.5	2	3	3	10.5	2.6
21	7.5	9	8.5	8	33.0	8.3

Analysis of Variance						
Source	df	ss	ms	F	5%	1%
Total	83	3492.5				
Reps	3	13.7				
Lines	20	3098.1	154.9	24.4 ^{xx}	1.75	2.20
Error	60	380.7	6.35			

$$\text{L.S.D.} - t_{.05} - 2.00 \times 1.79 = 3.58$$

$$t_{.01} - 2.66 \times 1.79 = 4.76$$

Table 32

Chinese Spring lines with substituted Timstein chromosomes

Chromosome tested	Lodging				Total	1953 Average
	Series 1	Series 2	Series 3	Series 4		
Timstein	9.8	8.0	9.6	9.8	37.2	9.3
Chinese Spring	5.2	4.0	5.2	6.2	20.6	5.15
1	6.8	7.0	8.0	6.6	28.4	7.1
2	6.8	4.6	6.6	4.2	22.2	5.55
3	5.8	3.8	5.8	7.0	22.4	5.6
4	7.2	5.0	6.6	7.4	26.2	6.55
5	8.6	8.4	7.2	5.4	29.6	7.4
6	5.8	5.2	6.8	5.8	23.6	5.9
7	6.0	4.6	5.8	6.2	22.6	5.65
8	8.4	8.4	8.6	8.8	34.2	8.55
9	5.6	3.8	5.2	4.0	18.6	4.65
10	8.2	8.4	8.2	8.8	33.6	8.4
11	6.0	3.6	5.6	6.2	21.4	5.35
12	5.4	5.4	5.2	6.0	22.0	5.5
15	6.2	4.2	6.8	5.4	22.6	5.65
16	3.8	5.2	7.6	6.8	23.4	5.85
17	6.6	4.0	7.4	6.2	24.2	6.05
18	3.8	7.0	7.0	5.6	23.4	5.85
19	7.6	8.8	8.6	8.0	33.0	8.25
20	4.0	3.2	5.8	5.6	18.6	4.65
21	5.8	4.8	5.8	4.4	20.8	5.2

Analysis of Variance

Source	df	ss	ms	F	5%	1%
Total	83	211.52				
Reps	3	16.71	5.57	6.32 ^{xx}		
Lines	20	144.93	7.25	8.24 ^{xx}	1.75	2.20
Error	60	52.88	0.881			

L.S.D. (1) 5% point - $t_{.05} = 2.000 \times .66 = 1.32$ (11) 1% point - $t_{.01} = 2.660 \times .66 = 1.76$

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A	B	C	D	E	F	G
H	I	J	K	L	M	N
O	P	Q	R	S	T	U
V	W	X	Y	Z	AA	AB
AC	AD	AE	AF	AG	AH	AI
AJ	AK	AL	AM	AN	AO	AP
AQ	AR	AS	AT	AU	AV	AW
AX	AY	AZ	BA	BB	BC	BD
BE	BF	BG	BH	BI	BJ	BK
BL	BM	BN	BO	BP	BQ	BR
BS	BT	BU	BV	BW	BX	BY
BZ	CA	CB	CC	CD	CE	CF
CG	CH	CI	CJ	CK	CL	CM
CN	CO	CP	CQ	CR	CS	CT
CU	CV	CW	CX	CY	CZ	DA
DB	DC	DD	DE	DF	DG	DH
DI	DJ	DK	DL	DM	DN	DO
DP	DQ	DR	DS	DT	DU	DV
DW	DX	DY	DZ	EA	EB	EC
ED	EE	EF	EG	EH	EI	EJ
EK	EL	EM	EN	EO	EP	EQ
ER	ES	ET	EU	EV	EW	EX
EY	EZ	FA	FB	FC	FD	FE
FF	FG	FH	FI	FJ	FK	FL
FM	FN	FO	FP	FQ	FR	FS
FT	FU	FV	FW	FX	FY	FZ
GA	GB	GC	GD	GE	GF	GG
GH	GI	GJ	GK	GL	GM	GN
GO	GP	GQ	GR	GS	GT	GU
GV	GW	GX	GY	GZ	HA	HB
HC	HD	HE	HF	HG	HH	HI
HJ	HK	HL	HM	HN	HO	HP
HQ	HR	HS	HT	HU	HV	HW
HX	HY	HZ	IA	IB	IC	ID
IE	IF	IG	IH	II	IJ	IK
IL	IM	IN	IO	IP	IQ	IR
IS	IT	IU	IV	IW	IX	IY
IZ	JA	JB	JC	JD	JE	JF
JG	JH	JI	JJ	JK	JL	JM
JN	JO	JP	JQ	JR	JS	JT
JU	JV	JW	JX	JY	JZ	KA
KB	KC	KD	KE	KF	KG	KH
KI	KJ	KK	KL	KM	KN	KO
KP	KQ	KR	KS	KT	KU	KV
KW	KX	KY	KZ	LA	LB	LC
LD	LE	LF	LG	LH	LI	LJ
LK	LL	LM	LN	LO	LP	LQ
LR	LS	LT	LU	LV	LW	LX
LY	LZ	MA	MB	MC	MD	ME
MF	MG	MH	MI	MJ	MK	ML
MM	MN	MO	MP	MQ	MR	MS
MT	MU	MV	MW	MX	MY	MZ
NA	NB	NC	ND	NE	NF	NG
NH	NI	NJ	NK	NL	NO	NP
NQ	NR	NS	NT	NU	NV	NW
NX	NY	NZ	OA	OB	OC	OD
OE	OF	OG	OH	OI	OJ	OK
OL	OM	ON	OO	OP	OQ	OR
OS	OT	OU	OV	OW	OX	OY
OZ	PA	PB	PC	PD	PE	PF
PG	PH	PI	PJ	PK	PL	PM
PN	PO	PP	PQ	PR	PS	PT
PU	PV	PW	PX	PY	PZ	QA
QB	QC	QD	QE	QF	QG	QH
QI	QJ	QK	QL	QM	QN	QO
QP	QQ	QR	QS	QT	QU	QV
QW	QX	QY	QZ	RA	RB	RC
RD	RE	RF	RG	RH	RI	RJ
RK	RL	RM	RN	RO	RP	RQ
RR	RS	RT	RU	RV	RW	RX
RY	RZ	SA	SB	SC	SD	SE
SF	SG	SH	SI	SJ	SK	SL
SM	SN	SO	SP	SQ	SR	SS
ST	SU	SV	SW	SX	SY	SZ
TA	TB	TC	TD	TE	TF	TG
TH	TI	TJ	TK	TL	TM	TN
TO	TP	TQ	TR	TS	TT	TU
TV	TW	TX	TY	TZ	UA	UB
UC	UD	UE	UF	UG	UH	UI
UJ	UK	UL	UM	UN	UO	UP
UQ	UR	US	UT	UU	UV	UW
UX	UY	UZ	VA	VB	VC	VD
VE	VF	VG	VH	VI	VJ	VK
VL	VM	VN	VO	VP	VQ	VR
VS	VT	VU	VV	VW	VX	VY
VZ	WA	WB	WC	WD	WE	WF
WG	WH	WI	WJ	WK	WL	WM
WN	WO	WP	WQ	WR	WS	WT
WU	WV	WW	WX	WY	WZ	XA
XB	XC	XD	XE	XF	XG	XH
XI	XJ	XK	XL	XM	XN	XO
XP	XQ	XR	XS	XT	XU	XV
XW	XX	XY	XZ	YA	YB	YC
YD	YE	YF	YG	YH	YI	YJ
YK	YL	YM	YN	YO	YP	YQ
YR	YS	YT	YU	YV	YW	YX
YY	YZ	ZA	ZB	ZC	ZD	ZE
ZF	ZG	ZH	ZI	ZJ	ZK	ZL
ZM	ZN	ZO	ZA	ZB	ZC	ZD

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CHICAGO, ILLINOIS 60637
TEL: 773-707-3000
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Table 33

Chinese Spring lines with substituted Timstein chromosomes

Chromosome tested	Series 1	Lodging		Series 4	Total	1954 Average
		Series 2	Series 3			
Timstein	10	10	10	10	40.0	10
Chinese Spring	4	3	3	4	14.0	3.5
1	7	5.5	7	8	27.5	6.9
2	6	7	7	7	27.0	6.8
3	4	5.5	6	5	20.5	5.1
4	6	5.5	7	7	25.5	6.4
5	9	9	7	8.5	33.5	8.4
6	6	6.5	6	6	24.5	6.1
7	6	5.5	6	6	23.5	5.9
8	7	7.5	7	9	30.5	7.6
9	8	8.5	8.5	9	34.0	8.5
10	7	8	7	7	29.0	7.3
11	5	5	6	6	22.0	5.5
12	7	7	6	8	28.0	7.0
15	7.5	6	7	7.5	28.0	7.0
16	6.5	4	4	5	19.5	4.9
17	5.5	7	6	6.5	25.0	6.3
18	6.5	7	7	7	27.5	6.9
19	7	7	7	9	30.0	7.5
20	3	3	4	4	14.0	3.5
21	3	4	4.5	4.5	16.0	4.0
Analysis of Variance						
Source	df	ss	ms	F	5%	1%
Total	83	2462.5				
Reps	3	53.9				
Lines	20	2148.1	107.4 ^{xxx}	2.47	1.75	2.20
Error	60	260.5	4.34			

L.S.D. - 5% point - $1.47 \times 2.00 = 2.94$ 1% point - $1.47 \times 2.66 = 3.91$

ESTIMATE OF THE TOTAL NUMBER OF INSECTS IN THE SAMPLE

No. of specimens	Total weight	Number of specimens				Total weight
		1	2	3	4	
10	10.0	10	10	10	10	10.0
20	20.0	20	20	20	20	20.0
30	30.0	30	30	30	30	30.0
40	40.0	40	40	40	40	40.0
50	50.0	50	50	50	50	50.0
60	60.0	60	60	60	60	60.0
70	70.0	70	70	70	70	70.0
80	80.0	80	80	80	80	80.0
90	90.0	90	90	90	90	90.0
100	100.0	100	100	100	100	100.0
110	110.0	110	110	110	110	110.0
120	120.0	120	120	120	120	120.0
130	130.0	130	130	130	130	130.0
140	140.0	140	140	140	140	140.0
150	150.0	150	150	150	150	150.0
160	160.0	160	160	160	160	160.0
170	170.0	170	170	170	170	170.0
180	180.0	180	180	180	180	180.0
190	190.0	190	190	190	190	190.0
200	200.0	200	200	200	200	200.0
210	210.0	210	210	210	210	210.0
220	220.0	220	220	220	220	220.0
230	230.0	230	230	230	230	230.0
240	240.0	240	240	240	240	240.0
250	250.0	250	250	250	250	250.0
260	260.0	260	260	260	260	260.0
270	270.0	270	270	270	270	270.0
280	280.0	280	280	280	280	280.0
290	290.0	290	290	290	290	290.0
300	300.0	300	300	300	300	300.0
310	310.0	310	310	310	310	310.0
320	320.0	320	320	320	320	320.0
330	330.0	330	330	330	330	330.0
340	340.0	340	340	340	340	340.0
350	350.0	350	350	350	350	350.0
360	360.0	360	360	360	360	360.0
370	370.0	370	370	370	370	370.0
380	380.0	380	380	380	380	380.0
390	390.0	390	390	390	390	390.0
400	400.0	400	400	400	400	400.0
410	410.0	410	410	410	410	410.0
420	420.0	420	420	420	420	420.0
430	430.0	430	430	430	430	430.0
440	440.0	440	440	440	440	440.0
450	450.0	450	450	450	450	450.0
460	460.0	460	460	460	460	460.0
470	470.0	470	470	470	470	470.0
480	480.0	480	480	480	480	480.0
490	490.0	490	490	490	490	490.0
500	500.0	500	500	500	500	500.0
510	510.0	510	510	510	510	510.0
520	520.0	520	520	520	520	520.0
530	530.0	530	530	530	530	530.0
540	540.0	540	540	540	540	540.0
550	550.0	550	550	550	550	550.0
560	560.0	560	560	560	560	560.0
570	570.0	570	570	570	570	570.0
580	580.0	580	580	580	580	580.0
590	590.0	590	590	590	590	590.0
600	600.0	600	600	600	600	600.0
610	610.0	610	610	610	610	610.0
620	620.0	620	620	620	620	620.0
630	630.0	630	630	630	630	630.0
640	640.0	640	640	640	640	640.0
650	650.0	650	650	650	650	650.0
660	660.0	660	660	660	660	660.0
670	670.0	670	670	670	670	670.0
680	680.0	680	680	680	680	680.0
690	690.0	690	690	690	690	690.0
700	700.0	700	700	700	700	700.0
710	710.0	710	710	710	710	710.0
720	720.0	720	720	720	720	720.0
730	730.0	730	730	730	730	730.0
740	740.0	740	740	740	740	740.0
750	750.0	750	750	750	750	750.0
760	760.0	760	760	760	760	760.0
770	770.0	770	770	770	770	770.0
780	780.0	780	780	780	780	780.0
790	790.0	790	790	790	790	790.0
800	800.0	800	800	800	800	800.0
810	810.0	810	810	810	810	810.0
820	820.0	820	820	820	820	820.0
830	830.0	830	830	830	830	830.0
840	840.0	840	840	840	840	840.0
850	850.0	850	850	850	850	850.0
860	860.0	860	860	860	860	860.0
870	870.0	870	870	870	870	870.0
880	880.0	880	880	880	880	880.0
890	890.0	890	890	890	890	890.0
900	900.0	900	900	900	900	900.0
910	910.0	910	910	910	910	910.0
920	920.0	920	920	920	920	920.0
930	930.0	930	930	930	930	930.0
940	940.0	940	940	940	940	940.0
950	950.0	950	950	950	950	950.0
960	960.0	960	960	960	960	960.0
970	970.0	970	970	970	970	970.0
980	980.0	980	980	980	980	980.0
990	990.0	990	990	990	990	990.0
1000	1000.0	1000	1000	1000	1000	1000.0

$$1000 \times 1000 = 1,000,000$$

$$1000 \times 1000 = 1,000,000$$

Table 34

Computation of lines x years interaction of spike density from composite of 3 sets of substitution lines in 1953 and 1954.

Chromosome tested	Thatcher				Hope				Tinstein			
	1953		1954		1953		1954		1953		1954	
	Rep 1	Rep 2	Rep 1	Rep 2	Rep 1	Rep 2	Rep 1	Rep 2	Rep 1	Rep 2	Rep 1	Rep 2
Chinese Spring	2.93	2.89	3.48	3.46	2.96	2.99	3.29	3.56	2.79	2.93	3.45	3.52
1	2.73	2.73	3.22	3.04	2.96	2.95	3.30	3.19	2.96	2.81	3.20	3.37
2	2.76	2.73	3.21	3.32	3.20	3.27	3.78	3.68	2.90	2.94	3.63	3.65
3	2.41	2.36	2.95	3.00	2.88	2.76	3.30	3.25	2.64	2.58	3.00	3.07
4	3.11	3.04	3.61	3.61	2.92	2.78	3.25	3.33	2.96	3.06	3.57	3.70
5	2.76	2.76	3.16	3.04	2.76	2.76	3.15	3.08	2.71	2.68	3.08	3.37
6	2.42	2.37	3.10	2.97	2.67	2.60	2.94	3.17	2.71	2.64	3.18	3.24
7	2.64	2.66	3.10	3.16	2.69	2.72	3.46	3.22	2.68	2.65	3.39	3.36
8	2.33	2.30	2.76	2.85	2.49	2.41	2.97	2.89	2.65	2.62	3.11	3.20
9	2.55	2.48	2.90	2.97	3.18	3.10	3.91	3.25	2.80	2.89	3.74	3.69
10	2.21	2.40	2.92	2.55	2.22	2.25	2.83	2.66	2.79	2.77	3.04	3.09
11	2.89	2.70	3.31	3.34	2.92	2.87	3.32	3.06	2.66	2.67	3.16	3.06
12	2.46	2.54	3.00	3.18	3.20	3.19	3.78	3.36	3.20	3.15	3.76	3.86
15	2.69	2.69	3.55	3.26	2.73	2.99	3.03	3.43	3.17	3.11	3.42	3.43
16	2.83	2.81	3.52	3.36	2.97	3.01	3.32	3.54	2.74	2.70	3.28	3.25
19	2.65	2.57	3.08	2.96	2.86	2.93	3.17	3.14	2.66	2.70	3.15	3.12
20	2.53	2.56	3.34	3.21	2.47	2.13	3.00	2.92	2.25	2.24	2.71	2.79
21	2.59	2.59	3.00	2.86	2.77	2.78	3.30	3.16	2.81	2.72	3.21	3.20

Table 34 (continued)

Source	Analysis of Variance				
	<u>df</u>	<u>ss</u>	<u>ms</u>	<u>F</u>	<u>5%</u> <u>1%</u>
Total	215	27.73			
Reps	1	0			
Varieties	2	1.11	0.55		
Years	1	13.28	13.28		
Y x V	2	0.04	0.02		
Error (1)	5	0.10	0.02		
Lines	17	7.63	0.45		
L x Y	17	0.28	0.01647	0.15	
L x V	34	3.72	0.10941 ^{xx}	10.63	1.84
L x Y x V	34	0.52	0.01529	1.49	1.84
Error (2)	102	1.05	0.01029		
<hr/>					
	<u>LxYxV</u>	<u>LxV</u>	<u>L</u>		
L.S.D.	5% level	0.1984 (0.2)	0.20	0.38	
	1% level	0.2626 (0.26)	0.26	0.52	

Table 35

Computation of lines x varieties interaction of spike density from composite of 3 sets of substitution lines in 1953.

Chromosome tested	Thatcher	Ave.		Hope	Ave.		Timstein	Ave.	
Chinese Spring	2.79	2.89	2.93	2.79	2.99	2.96	2.99	2.92	2.79
1	2.58	2.77	2.73	2.70	2.83	2.96	2.95	2.81	2.96
2	2.71	2.62	2.76	2.71	3.36	3.27	3.28	2.93	2.90
3	2.30	2.30	2.41	2.34	2.72	2.79	2.76	2.45	2.64
4	3.08	3.04	3.11	3.07	2.77	2.95	2.86	2.92	2.96
5	2.65	2.60	2.76	2.69	2.68	2.70	2.76	2.64	2.62
6	2.33	2.39	2.42	2.38	2.53	2.70	2.67	2.56	2.71
7	2.66	2.54	2.64	2.63	2.59	2.84	2.69	2.79	2.68
8	2.26	2.32	2.33	2.30	2.36	2.38	2.49	2.41	2.68
9	2.48	2.56	2.55	2.52	3.02	3.03	3.18	3.10	2.77
10	2.45	2.46	2.21	2.38	2.18	2.22	2.22	2.25	2.68
11	2.71	2.80	2.89	2.78	2.83	2.93	2.92	2.87	2.68
12	2.46	2.52	2.46	2.50	3.28	3.15	3.20	3.19	3.09
15	2.59	2.66	2.69	2.66	2.75	2.90	2.73	2.99	3.00
16	2.69	2.87	2.83	2.80	2.97	3.06	2.97	3.01	2.70
17	2.67	2.59	2.67	2.64	2.58	2.66	2.70	2.66	2.81
19	2.57	2.61	2.65	2.60	2.82	2.81	2.86	2.93	2.80
20	2.53	2.51	2.53	2.53	2.27	2.43	2.47	2.13	2.12
21	2.48	2.49	2.59	2.54	2.66	2.67	2.77	2.78	2.65

Analysis of Variance

Source	df	ss	ms	F	5%	1%
Total	227					
Reps	3	.1	.0333			
Varieties	2	1.4	0.700			
Error (1)	6	0.0	.00			
Lines	19	7.5	0.394			
Lines x varieties	38	3.9	0.102	23.18 ^{xx}	1.48	1.75
Error (2)	159	0.7	0.0044			
L.S.D.	5% level	1.978 x 0.0469 = 0.093				
	1% level	2.614 x 0.0469 = 0.123				

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4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1041

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1999年，在《中国农村扶贫开发纲要（2001—2010年）》中，首次提出“农村扶贫开发”的概念，并指出“农村扶贫开发是农村经济和社会发展的基础，是农村脱贫致富的根本途径”。

Table 36

Computation of lines x varieties interaction of spike density from composite
of 3 sets of substitution lines in 1954.

Chromosome tested	Hope	Timstein	Thatcher
Chinese Spring	3.29	3.45	3.52
1	3.30	3.20	3.37
2	3.78	3.63	3.65
3	3.30	3.00	3.07
4	3.25	3.57	3.70
5	3.33	3.08	3.37
6	3.15	3.18	3.24
7	2.94	3.39	3.36
8	3.46	3.11	3.20
9	2.97	3.74	3.69
10	3.91	3.04	2.90
11	2.83	3.16	2.92
12	3.32	3.06	3.31
13	3.78	3.36	3.86
14	3.03	3.43	3.43
15	3.32	3.28	3.25
16	3.37	3.47	3.60
17	3.17	3.15	3.12
18	3.00	2.71	2.79
19	3.30	3.21	3.20
20			
21			

Analysis of Variance

Source	df	ss	ms	F	5%	1%
Total	113	8.1031				
Reps	1	0.0165	0.0165			
Varieties	2	0.4900	0.2450			
Error (1)	2	0.0861	0.4305			
Lines	18	4.4672	0.2481			
Lines x Varieties	36	2.2423	0.0622	3.49 ^{xxx}	1.69	2.10
Error (2)	54	0.9642	0.0178			
L.S.D.	5% level - 0.133 x 2.005 = 0.27					
	1% level - 0.133 x 2.671 = 0.36					

Table 37

Chinese Spring lines with substituted Thatcher chromosomes

Chromosome tested	Spike Length (centimeters)				Total	1952 Average
	Series 1	Series 2	Series 3	Series 4		
Thatcher	7.3	6.7	7.0	7.0	28.0	7.0
Chinese Spring	6.7	6.4	6.3	6.6	26.0	6.5
1	6.8	7.1	6.5	6.8	27.2	6.8
2	6.5	6.3	6.1	6.3	25.2	6.3
3	6.4	6.7	7.0	6.7	26.8	6.7
4	5.5	5.7	5.4	5.4	22.0	5.5
5	6.2	6.4	6.0	6.2	24.8	6.2
6	6.7	7.0	6.5	6.6	26.8	6.7
7	5.8	6.0	5.7	5.8	23.3	5.8
8	6.0	5.7	5.8	5.8	23.3	5.8
9	7.1	7.0	6.8	6.8	27.7	6.9
10	7.4	7.1	7.0	6.9	28.4	7.1
11	7.1	7.1	6.9	7.3	28.4	7.1
12	5.9	5.7	5.6	6.0	23.2	5.8
15	6.3	6.1	6.0	6.0	24.4	6.1
16	4.6	4.9	5.2	4.9	19.6	4.9
17	6.9	6.7	7.1	6.7	27.4	6.9
19	6.6	6.4	6.7	6.3	26.0	6.5
20	5.8	6.2	6.0	6.0	24.0	6.0
21	7.4	7.6	7.5	7.4	29.9	7.5

Source	df	Analysis of Variance			5%	1%
		ss	ms	F		
Total	83	328.98				
Reps	3	1.33	0.443			
Lines	20	308.58	15.43	48.52 ^{xx}	1.75	2.20
Error	60	19.07	0.318			

L.S.D. (1) 5% point - $t_{.05} - .4 \times 2.0 = 0.80$

(11) 1% point - $t_{.01} - .2 \times 2.66 = 1.064$

Method	1	2	3	4	5	6
Chinese	1.0	1.0	1.0	1.0	1.0	1.0
Chinese	1.0	1.0	1.0	1.0	1.0	1.0
1	1.0	1.0	1.0	1.0	1.0	1.0
2	1.0	1.0	1.0	1.0	1.0	1.0
3	1.0	1.0	1.0	1.0	1.0	1.0
4	1.0	1.0	1.0	1.0	1.0	1.0
5	1.0	1.0	1.0	1.0	1.0	1.0
6	1.0	1.0	1.0	1.0	1.0	1.0
7	1.0	1.0	1.0	1.0	1.0	1.0
8	1.0	1.0	1.0	1.0	1.0	1.0
9	1.0	1.0	1.0	1.0	1.0	1.0
10	1.0	1.0	1.0	1.0	1.0	1.0
11	1.0	1.0	1.0	1.0	1.0	1.0
12	1.0	1.0	1.0	1.0	1.0	1.0
13	1.0	1.0	1.0	1.0	1.0	1.0
14	1.0	1.0	1.0	1.0	1.0	1.0
15	1.0	1.0	1.0	1.0	1.0	1.0
16	1.0	1.0	1.0	1.0	1.0	1.0
17	1.0	1.0	1.0	1.0	1.0	1.0
18	1.0	1.0	1.0	1.0	1.0	1.0
19	1.0	1.0	1.0	1.0	1.0	1.0
20	1.0	1.0	1.0	1.0	1.0	1.0
21	1.0	1.0	1.0	1.0	1.0	1.0

Summary of the results

Method	1	2	3	4	5	6
Chinese	1.0	1.0	1.0	1.0	1.0	1.0
Chinese	1.0	1.0	1.0	1.0	1.0	1.0
1	1.0	1.0	1.0	1.0	1.0	1.0
2	1.0	1.0	1.0	1.0	1.0	1.0
3	1.0	1.0	1.0	1.0	1.0	1.0
4	1.0	1.0	1.0	1.0	1.0	1.0
5	1.0	1.0	1.0	1.0	1.0	1.0
6	1.0	1.0	1.0	1.0	1.0	1.0

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Table 38

Chinese Spring lines with substituted Thatcher chromosomes.

Chromosome tested	Series 1	No. of Spikelets			Total	1952 Average
		Series 2	Series 3	Series 4		
Thatcher	16.3	16.9	16.7	16.8	66.7	16.7
Chinese Spring	20.9	21.4	21.3	21.2	84.8	21.2
1	19.4	20.0	19.6	19.8	78.8	19.7
2	19.8	20.4	20.0	19.8	80.0	20.0
3	20.0	20.2	19.8	20.0	80.0	20.0
4	20.2	20.8	20.5	20.4	81.9	20.5
5	19.8	20.2	19.9	19.7	79.6	19.9
6	19.9	19.7	20.1	20.0	79.7	19.9
7	19.5	19.8	19.3	19.6	78.2	19.6
8	19.9	19.7	19.5	19.7	78.8	19.7
9	20.0	20.0	20.3	19.9	80.2	20.0
10	20.8	21.4	20.6	20.6	83.4	20.9
11	22.3	22.2	22.1	21.9	88.5	22.1
12	18.6	18.8	19.0	18.8	75.2	18.8
15	21.3	21.1	20.9	21.1	84.4	21.1
16	20.7	20.5	20.7	20.9	82.8	20.7
17	21.2	21.5	20.8	21.2	84.7	21.2
19	19.9	20.3	20.1	20.1	80.4	20.1
20	19.8	20.1	20.2	20.3	80.4	20.1
21	21.3	21.5	21.4	21.4	85.6	21.4

Analysis of Variance

<u>Source</u>	<u>df</u>	<u>ss</u>	<u>ms</u>	<u>F</u>	<u>5%</u>	<u>1%</u>
Total	79	99.79				
Reps	3	0.66	0.22			
Lines	19	96.96	5.10	134 ^{xxx}	1.77	2.25
Error	57	2.17	.0380			

L.S.D. (1) 5% point - $t_{.05} = 2.002 \times .14 = .28$ (11) 1% point - $t_{.01} = 2.666 \times .14 = .37$

Chinese Exports from the Republic of China, 1949-1954

Commodity Group	1949	1950	1951	1952	1953	1954
Grain	10.5	12.0	15.0	18.0	20.0	22.0
Oilseeds	8.0	9.0	10.0	11.0	12.0	13.0
Textiles	15.0	16.0	17.0	18.0	19.0	20.0
Metals	5.0	6.0	7.0	8.0	9.0	10.0
Chemicals	3.0	4.0	5.0	6.0	7.0	8.0
Transportation	2.0	3.0	4.0	5.0	6.0	7.0
Other	1.0	1.0	1.0	1.0	1.0	1.0
Total	44.5	51.0	60.0	70.0	78.0	86.0

Summary of Exports

Commodity Group	1949	1950	1951	1952	1953	1954
Grain	10.5	12.0	15.0	18.0	20.0	22.0
Oilseeds	8.0	9.0	10.0	11.0	12.0	13.0
Textiles	15.0	16.0	17.0	18.0	19.0	20.0
Metals	5.0	6.0	7.0	8.0	9.0	10.0
Chemicals	3.0	4.0	5.0	6.0	7.0	8.0
Transportation	2.0	3.0	4.0	5.0	6.0	7.0
Other	1.0	1.0	1.0	1.0	1.0	1.0
Total	44.5	51.0	60.0	70.0	78.0	86.0

Source: Ministry of Economic Affairs, Republic of China, Statistical Yearbook, 1955.

Table 39

Chinese Spring lines with substituted Thatcher chromosomes

Chromosome tested	Series 1	Spike Density			Total	1952 Average
		Series 2	Series 3	Series 4		
Thatcher	2.23	2.52	2.39	2.40	9.54	2.36
Chinese Spring	3.12	3.34	3.38	3.21	13.05	3.26
1	2.85	2.82	3.02	2.91	11.60	2.90
2	3.05	3.24	3.28	3.14	12.71	3.18
3	3.13	3.01	2.83	2.99	11.96	2.99
4	3.67	3.65	3.80	3.78	14.90	3.73
5	3.19	3.16	3.32	3.02	12.69	3.17
6	2.97	2.81	3.09	3.03	11.90	2.98
7	3.36	3.30	3.39	3.38	13.43	3.36
8	3.32	3.46	3.36	3.40	13.54	3.39
9	2.82	2.86	2.99	2.93	11.60	2.90
10	2.81	3.01	2.94	2.99	11.75	2.94
11	3.14	3.13	3.20	3.00	12.47	3.12
12	3.15	3.30	3.39	3.13	12.97	3.24
15	3.38	3.46	3.48	3.52	13.84	3.46
16	4.50	4.18	3.98	4.27	16.93	4.23
17	3.07	3.21	2.93	3.16	12.37	3.09
18						
19	3.02	3.17	3.00	3.19	12.38	3.10
20	3.41	3.24	3.36	3.38	13.39	3.35
21	2.88	2.83	2.85	2.89	11.45	2.86
Analysis of Variance						
Source	df	ss	ms	F	5%	1%
Total	79	11.22				
Reps	3	0.02	0.007	0.636		
Lines	19	10.56	0.556	50.545 ^{xxx}	1.77	2.25
Error	57	0.64	0.011			

$$\text{L.S.D. } t_{.05} = 2.002 \times 0.0742 = 0.149$$

$$t_{.01} = 2.666 \times 0.0742 = 0.198$$

Table 40

Chinese Spring lines with substituted Thatcher chromosomes

Chromosome tested	Spike Length (centimeters)				Total	1953 Average
	Series 1	Series 2	Series- 3	Series 4		
Thatcher	8.7	8.3	8.4	8.5	33.9	8.5
Chinese Spring	7.6	7.3	7.2	7.3	29.4	7.4
1	7.9	7.4	7.5	7.5	30.3	7.6
2	7.5	7.8	7.4	7.5	30.2	7.6
3	8.3	8.2	7.9	8.1	32.5	8.1
4	6.6	6.7	6.6	6.7	26.6	6.7
5	7.4	7.5	7.1	7.1	29.1	7.3
6	8.2	8.0	7.9	8.1	32.2	8.1
7	7.1	7.4	7.2	7.1	28.8	7.2
8	8.0	7.9	7.8	7.9	31.6	7.9
9	9.0	8.8	8.8	9.0	35.6	8.9
10	8.5	8.4	8.4	8.6	33.9	8.4
11	7.9	7.6	7.4	7.9	30.8	7.7
12	8.0	7.9	8.0	7.8	31.7	7.9
13	7.6	7.9	7.4	7.4	30.3	7.6
15	8.1	7.9	7.8	7.8	31.6	7.9
16	7.2	6.8	6.9	6.9	27.8	7.0
17	7.8	8.0	7.8	7.9	31.5	7.9
18	7.3	7.2	7.3	7.0	28.8	7.2
19	8.4	8.2	8.1	8.4	33.1	8.3
20	7.9	7.9	7.9	7.8	31.5	7.9
21	9.0	8.9	8.6	8.6	35.1	8.8

Linear Series (1908) (continued)

Station	Date	Water Level (Feet)				Remarks
		1	2	3	4	
1	1908	1.2	1.1	1.0	0.9	
2	1908	1.1	1.0	0.9	0.8	
3	1908	1.0	0.9	0.8	0.7	
4	1908	0.9	0.8	0.7	0.6	
5	1908	0.8	0.7	0.6	0.5	
6	1908	0.7	0.6	0.5	0.4	
7	1908	0.6	0.5	0.4	0.3	
8	1908	0.5	0.4	0.3	0.2	
9	1908	0.4	0.3	0.2	0.1	
10	1908	0.3	0.2	0.1	0.0	
11	1908	0.2	0.1	0.0	-0.1	
12	1908	0.1	0.0	-0.1	-0.2	
13	1908	0.0	-0.1	-0.2	-0.3	
14	1908	-0.1	-0.2	-0.3	-0.4	
15	1908	-0.2	-0.3	-0.4	-0.5	
16	1908	-0.3	-0.4	-0.5	-0.6	
17	1908	-0.4	-0.5	-0.6	-0.7	
18	1908	-0.5	-0.6	-0.7	-0.8	
19	1908	-0.6	-0.7	-0.8	-0.9	
20	1908	-0.7	-0.8	-0.9	-1.0	
21	1908	-0.8	-0.9	-1.0	-1.1	
22	1908	-0.9	-1.0	-1.1	-1.2	
23	1908	-1.0	-1.1	-1.2	-1.3	
24	1908	-1.1	-1.2	-1.3	-1.4	
25	1908	-1.2	-1.3	-1.4	-1.5	
26	1908	-1.3	-1.4	-1.5	-1.6	
27	1908	-1.4	-1.5	-1.6	-1.7	
28	1908	-1.5	-1.6	-1.7	-1.8	
29	1908	-1.6	-1.7	-1.8	-1.9	
30	1908	-1.7	-1.8	-1.9	-2.0	

Table 41

Chinese Spring lines with substituted Thatcher chromosomes

Chromosome tested	Series 1	Number of Spikelets			Total	1953
		Series 2	Series 3	Series 4		Average
Thatcher	16.6	16.6	16.6	16.5	66.3	16.6
Chinese Spring	21.2	21.1	21.1	21.1	84.5	21.1
1	20.4	20.5	20.5	20.5	81.9	20.5
2	20.3	20.4	20.4	20.5	81.6	20.4
3	19.1	18.9	19.0	19.1	76.1	19.0
4	20.3	20.4	20.5	20.4	81.6	20.4
5	19.6	19.5	19.6	19.6	78.3	19.6
6	19.1	19.1	19.1	19.2	76.5	19.1
7	18.9	18.8	19.0	18.9	75.6	18.9
8	18.1	18.3	18.2	18.2	72.8	18.2
9	22.3	22.5	22.4	22.3	89.5	22.4
10	20.8	20.7	20.6	20.6	82.7	20.7
11	21.4	21.3	21.4	21.3	85.4	21.4
12	19.7	19.9	19.7	19.8	79.1	19.8
13	22.6	22.7	22.7	22.6	90.6	22.7
14	21.0	21.0	21.0	21.0	84.0	21.0
16	19.4	19.5	19.5	19.4	77.8	19.5
17	20.8	20.7	20.8	20.7	83.0	20.8
18	22.6	22.7	22.6	22.7	90.6	22.7
19	21.6	21.4	21.5	21.6	86.1	21.5
20	20.0	19.8	20.1	20.0	79.9	20.0
21	22.3	22.2	22.3	22.3	89.1	22.3

Table 1. The results of the analysis of variance for the different parameters of the different groups.

Group	Parameter	Analysis of variance				Significance level
		Between groups	Within groups	Total	Error	
1	1.1	1.1	1.1	1.1	1.1	0.05
2	1.2	1.2	1.2	1.2	1.2	0.05
3	1.3	1.3	1.3	1.3	1.3	0.05
4	1.4	1.4	1.4	1.4	1.4	0.05
5	1.5	1.5	1.5	1.5	1.5	0.05
6	1.6	1.6	1.6	1.6	1.6	0.05
7	1.7	1.7	1.7	1.7	1.7	0.05
8	1.8	1.8	1.8	1.8	1.8	0.05
9	1.9	1.9	1.9	1.9	1.9	0.05
10	2.0	2.0	2.0	2.0	2.0	0.05
11	2.1	2.1	2.1	2.1	2.1	0.05
12	2.2	2.2	2.2	2.2	2.2	0.05
13	2.3	2.3	2.3	2.3	2.3	0.05
14	2.4	2.4	2.4	2.4	2.4	0.05
15	2.5	2.5	2.5	2.5	2.5	0.05
16	2.6	2.6	2.6	2.6	2.6	0.05
17	2.7	2.7	2.7	2.7	2.7	0.05
18	2.8	2.8	2.8	2.8	2.8	0.05
19	2.9	2.9	2.9	2.9	2.9	0.05
20	3.0	3.0	3.0	3.0	3.0	0.05
21	3.1	3.1	3.1	3.1	3.1	0.05
22	3.2	3.2	3.2	3.2	3.2	0.05
23	3.3	3.3	3.3	3.3	3.3	0.05
24	3.4	3.4	3.4	3.4	3.4	0.05
25	3.5	3.5	3.5	3.5	3.5	0.05
26	3.6	3.6	3.6	3.6	3.6	0.05
27	3.7	3.7	3.7	3.7	3.7	0.05
28	3.8	3.8	3.8	3.8	3.8	0.05
29	3.9	3.9	3.9	3.9	3.9	0.05
30	4.0	4.0	4.0	4.0	4.0	0.05

Table 42

Chinese Spring lines with substituted Thatcher chromosomes

Chromosome tested	Series 1	Spike Density			Total	1953 Average
		Series 2	Series 23	Series 4		
Thatcher	1.91	2.00	1.98	1.94	7.83	1.96
Chinese Spring	2.79	2.89	2.93	2.89	11.50	2.88
1	2.58	2.77	2.73	2.73	10.81	2.70
2	2.71	2.62	2.76	2.73	10.82	2.71
3	2.30	2.30	2.41	2.36	9.37	2.34
4	3.08	3.04	3.11	3.04	12.27	3.07
5	2.65	2.60	2.76	2.76	10.77	2.69
6	2.33	2.39	2.42	2.37	9.51	2.38
7	2.66	2.54	2.64	2.66	10.50	2.63
8	2.26	2.32	2.33	2.30	9.21	2.30
9	2.48	2.56	2.55	2.48	10.07	2.52
10	2.45	2.46	2.21	2.40	9.52	2.38
11	2.71	2.80	2.89	2.70	11.10	2.78
12	2.46	2.52	2.46	2.54	9.98	2.50
13	2.97	2.87	3.07	3.05	11.96	2.99
15	2.59	2.66	2.69	2.69	10.63	2.66
16	2.69	2.87	2.83	2.81	11.20	2.80
17	2.67	2.59	2.67	2.62	10.55	2.64
18	3.09	3.15	3.09	3.24	12.57	3.14
19	2.57	2.61	2.65	2.57	10.40	2.60
20	2.53	2.51	2.53	2.56	10.13	2.53
21	2.48	2.49	2.59	2.59	10.15	2.54
Analysis of Variance						
Source	df	ss	ms	F	5%	1%
Total	87	6.36				
Reps	3	0.04	0.01333	3.5		
Lines	21	6.08	0.2895	76.18	1.73	2.17
Error	63	0.24	0.0038			
L.S.D.	5% point - $0.044 \times 1.999 = 0.088$					
	1% point - $0.044 \times 2.657 = 0.117$					

Table 43

Chinese Spring lines with substituted Thatcher chromosomes

1954

Chromosome tested	Series 1	Spike Length		Average
		Series 2	Total	
Thatcher	7.1	6.7	13.8	6.90
Chinese Spring	6.2	6.5	12.7	6.35
1	6.5	6.7	13.2	6.60
2	6.6	5.9	12.5	6.25
3	6.6	6.4	13.0	6.50
4	5.9	5.7	11.6	5.80
5	6.0	6.2	12.2	6.10
6	6.9	6.9	13.8	6.90
7	6.2	5.8	12.0	6.00
8	7.0	6.6	13.6	6.80
9	7.4	7.5	14.9	7.45
10	7.5	8.0	15.5	7.75
11	6.8	6.8	13.6	6.80
12	6.5	6.2	12.7	6.35
13	7.1	7.0	14.1	7.05
15	6.1	6.5	12.6	6.30
16	6.0	6.1	12.1	6.05
18	6.5	6.8	13.3	6.65
19	7.1	7.2	14.3	7.15
20	6.5	6.2	12.7	6.35
21	7.5	7.5	15.0	7.50
22(10)	8.0	7.3	15.3	7.65
23(16)	6.1	6.3	12.4	6.20
24(19)	6.8	7.3	14.1	7.05

Estimated 1967-1968: Lines with asterisk (*) are estimated

1968

Production (thousand tons)	1	2	3	4
1967-1968	7.1	6.7	10.0	6.0
1968-1969	6.1	6.2	10.7	6.2
1	6.1	7.0	10.0	6.0
2	6.0	6.9	10.3	6.2
3	6.0	6.4	10.0	6.0
4	6.0	6.7	10.0	6.0
5	6.0	6.6	10.0	6.0
6	6.0	6.9	10.0	6.0
7	6.0	7.3	10.0	6.0
8	6.0	6.6	10.0	6.0
9	6.0	7.3	10.0	6.0
10	6.0	6.0	10.0	6.0
11	6.0	6.8	10.0	6.0
12	6.0	6.2	10.0	6.0
13	6.0	7.0	10.0	6.0
14	6.0	6.2	10.0	6.0
15	6.0	6.1	10.0	6.0
16	6.0	6.1	10.0	6.0
17	6.0	6.0	10.0	6.0
18	6.0	6.0	10.0	6.0
19	6.0	6.0	10.0	6.0
20	6.0	6.0	10.0	6.0
21	6.0	6.0	10.0	6.0
22	6.0	6.0	10.0	6.0
23	6.0	6.0	10.0	6.0
24	6.0	6.0	10.0	6.0
25	6.0	6.0	10.0	6.0
26	6.0	6.0	10.0	6.0
27	6.0	6.0	10.0	6.0
28	6.0	6.0	10.0	6.0
29	6.0	6.0	10.0	6.0
30	6.0	6.0	10.0	6.0
31	6.0	6.0	10.0	6.0
32	6.0	6.0	10.0	6.0
33	6.0	6.0	10.0	6.0
34	6.0	6.0	10.0	6.0
35	6.0	6.0	10.0	6.0
36	6.0	6.0	10.0	6.0
37	6.0	6.0	10.0	6.0
38	6.0	6.0	10.0	6.0
39	6.0	6.0	10.0	6.0
40	6.0	6.0	10.0	6.0
41	6.0	6.0	10.0	6.0
42	6.0	6.0	10.0	6.0
43	6.0	6.0	10.0	6.0
44	6.0	6.0	10.0	6.0
45	6.0	6.0	10.0	6.0
46	6.0	6.0	10.0	6.0
47	6.0	6.0	10.0	6.0
48	6.0	6.0	10.0	6.0
49	6.0	6.0	10.0	6.0
50	6.0	6.0	10.0	6.0
51	6.0	6.0	10.0	6.0
52	6.0	6.0	10.0	6.0
53	6.0	6.0	10.0	6.0
54	6.0	6.0	10.0	6.0
55	6.0	6.0	10.0	6.0
56	6.0	6.0	10.0	6.0
57	6.0	6.0	10.0	6.0
58	6.0	6.0	10.0	6.0
59	6.0	6.0	10.0	6.0
60	6.0	6.0	10.0	6.0
61	6.0	6.0	10.0	6.0
62	6.0	6.0	10.0	6.0
63	6.0	6.0	10.0	6.0
64	6.0	6.0	10.0	6.0
65	6.0	6.0	10.0	6.0
66	6.0	6.0	10.0	6.0
67	6.0	6.0	10.0	6.0
68	6.0	6.0	10.0	6.0
69	6.0	6.0	10.0	6.0
70	6.0	6.0	10.0	6.0
71	6.0	6.0	10.0	6.0
72	6.0	6.0	10.0	6.0
73	6.0	6.0	10.0	6.0
74	6.0	6.0	10.0	6.0
75	6.0	6.0	10.0	6.0
76	6.0	6.0	10.0	6.0
77	6.0	6.0	10.0	6.0
78	6.0	6.0	10.0	6.0
79	6.0	6.0	10.0	6.0
80	6.0	6.0	10.0	6.0
81	6.0	6.0	10.0	6.0
82	6.0	6.0	10.0	6.0
83	6.0	6.0	10.0	6.0
84	6.0	6.0	10.0	6.0
85	6.0	6.0	10.0	6.0
86	6.0	6.0	10.0	6.0
87	6.0	6.0	10.0	6.0
88	6.0	6.0	10.0	6.0
89	6.0	6.0	10.0	6.0
90	6.0	6.0	10.0	6.0
91	6.0	6.0	10.0	6.0
92	6.0	6.0	10.0	6.0
93	6.0	6.0	10.0	6.0
94	6.0	6.0	10.0	6.0
95	6.0	6.0	10.0	6.0
96	6.0	6.0	10.0	6.0
97	6.0	6.0	10.0	6.0
98	6.0	6.0	10.0	6.0
99	6.0	6.0	10.0	6.0
100	6.0	6.0	10.0	6.0

Analysis of Variance

<u>Source</u>	<u>df</u>	<u>SS</u>	<u>ms</u>	<u>F</u>	<u>5%</u>	<u>1%</u>
Total	47	15.09	0.32			
Reps	1	0.01	0.01	0.16		
Lines	23	13.73	0.597	10.119 ^{xx}	2.01	2.72
Error	23	1.35	0.059			

L.S.D. 5% point - $2.069 \times 0.2429 = 0.5026$

1% point - $2.807 \times 0.2429 = 0.6818$

Table 44

Chinese Spring lines with substituted Thatcher chromosomes

Chromosome tested	Number of Spikelets		Total	Average	1954
	Series 3	Series 4			
Thatcher	16.3	15.5	31.8	15.9	
Chinese Spring	21.6	22.5	44.1	22.15	
1	20.9	20.4	41.3	20.65	
2	21.2	19.6	40.8	20.4	
3	19.5	19.3	38.8	19.4	
4	21.3	21.3	42.6	21.3	
5	19.0	18.9-	57.9	18.95	
6	20.8	20.5	41.3	20.65	
7	19.7	18.3	38.0	19.0	
8	19.4	18.8	38.2	19.1	
9	21.4	22.5	43.9	21.95	
10	21.3	21.7	43.0	21.5	
11	22.5	22.7	45.2	22.6	
12	19.5	19.7	39.2	19.6	
13	22.2	23.1	45.3	22.65	
15	21.7	21.5	43.2	21.60	
16	21.1	20.5	41.6	20.8	
18	22.1	22.5	44.6	22.3	
19	21.9	21.3	43.2	21.6	
20	21.7	19.9	41.6	20.8	
21	22.5	21.4	43.9	21.95	
22(10)	21.3	21.3	42.6	21.3	
23(16)	21.2	21.1	42.3	21.15	
24(19)	22.0	21.3	43.3	21.65	

Table showing the results of the experiments conducted during the year 1910.

Date	Temperature		Time	Remarks
	Air	Water		
Jan 1	32.0	32.0	1.00	Normal
Jan 2	32.5	32.5	1.00	Normal
Jan 3	33.0	33.0	1.00	Normal
Jan 4	33.5	33.5	1.00	Normal
Jan 5	34.0	34.0	1.00	Normal
Jan 6	34.5	34.5	1.00	Normal
Jan 7	35.0	35.0	1.00	Normal
Jan 8	35.5	35.5	1.00	Normal
Jan 9	36.0	36.0	1.00	Normal
Jan 10	36.5	36.5	1.00	Normal
Jan 11	37.0	37.0	1.00	Normal
Jan 12	37.5	37.5	1.00	Normal
Jan 13	38.0	38.0	1.00	Normal
Jan 14	38.5	38.5	1.00	Normal
Jan 15	39.0	39.0	1.00	Normal
Jan 16	39.5	39.5	1.00	Normal
Jan 17	40.0	40.0	1.00	Normal
Jan 18	40.5	40.5	1.00	Normal
Jan 19	41.0	41.0	1.00	Normal
Jan 20	41.5	41.5	1.00	Normal
Jan 21	42.0	42.0	1.00	Normal
Jan 22	42.5	42.5	1.00	Normal
Jan 23	43.0	43.0	1.00	Normal
Jan 24	43.5	43.5	1.00	Normal
Jan 25	44.0	44.0	1.00	Normal
Jan 26	44.5	44.5	1.00	Normal
Jan 27	45.0	45.0	1.00	Normal
Jan 28	45.5	45.5	1.00	Normal
Jan 29	46.0	46.0	1.00	Normal
Jan 30	46.5	46.5	1.00	Normal
Jan 31	47.0	47.0	1.00	Normal
Feb 1	47.5	47.5	1.00	Normal
Feb 2	48.0	48.0	1.00	Normal
Feb 3	48.5	48.5	1.00	Normal
Feb 4	49.0	49.0	1.00	Normal
Feb 5	49.5	49.5	1.00	Normal
Feb 6	50.0	50.0	1.00	Normal
Feb 7	50.5	50.5	1.00	Normal
Feb 8	51.0	51.0	1.00	Normal
Feb 9	51.5	51.5	1.00	Normal
Feb 10	52.0	52.0	1.00	Normal
Feb 11	52.5	52.5	1.00	Normal
Feb 12	53.0	53.0	1.00	Normal
Feb 13	53.5	53.5	1.00	Normal
Feb 14	54.0	54.0	1.00	Normal
Feb 15	54.5	54.5	1.00	Normal
Feb 16	55.0	55.0	1.00	Normal
Feb 17	55.5	55.5	1.00	Normal
Feb 18	56.0	56.0	1.00	Normal
Feb 19	56.5	56.5	1.00	Normal
Feb 20	57.0	57.0	1.00	Normal
Feb 21	57.5	57.5	1.00	Normal
Feb 22	58.0	58.0	1.00	Normal
Feb 23	58.5	58.5	1.00	Normal
Feb 24	59.0	59.0	1.00	Normal
Feb 25	59.5	59.5	1.00	Normal
Feb 26	60.0	60.0	1.00	Normal
Feb 27	60.5	60.5	1.00	Normal
Feb 28	61.0	61.0	1.00	Normal
Feb 29	61.5	61.5	1.00	Normal
Feb 30	62.0	62.0	1.00	Normal
Feb 31	62.5	62.5	1.00	Normal

Analysis of Variance

<u>Source</u>	<u>df</u>	<u>ss</u>	<u>ms</u>	<u>F</u>	<u>5%</u>	<u>1%</u>
Total	47	114.22				
Reps	1	0.88	0.88	3.099		
Lines	23	106.80	4.643	16.349 ²⁰⁰	2.01	2.72
Error	23	6.54	0.284			

$$\text{L.S.D. } 5\% \text{ point} = 2.000 \times .532 = 1.06$$

$$1\% \text{ point} = 2.660 \times .532 = 1.42$$

ANALYSIS OF RESULTS

ST	ED	Y	AD	AS	AT	ANALYSIS
		100.0	100.0	100.0	1	100.0
97.0	97.0	100.0	100.0	100.0	10	100.0
			100.0	100.0	10	100.0

100.0 - 100.0 = 0.0 - 100.0 = 100.0

100.0 - 100.0 = 0.0 - 100.0 = 100.0

Table 45

Chinese Spring lines with substituted Thatcher chromosomes

Chromosome tested	Series 3	Spike Density		Average	1954
		Series 4	Total		
Thatcher	2.30	2.31	4.61	2.31	
Chinese Spring	3.48	3.46	6.94	3.47	
1	3.22	3.04	6.26	3.13	
2	3.21	3.32	6.53	3.27	
3	2.95	3.00	5.95	2.98	
4	3.61	3.61	7.22	3.61	
5	3.16	3.04	6.20	3.10	
6	3.10	2.97	6.07	3.04	
7	3.10	3.16	6.26	3.13	
8	2.76	2.85	5.61	2.81	
9	2.90	2.97	5.87	2.94	
10	2.92	2.55	5.47	2.74	
11	3.31	3.34	6.65	3.33	
12	3.00	3.18	6.18	3.09	
13	3.13	3.30	6.43	3.22	
15	3.55	3.26	6.81	3.41	
16	3.52	3.36	6.88	3.44	
18	3.40	3.31	6.71	3.36	
19	3.08	2.96	6.04	3.02	
20	3.34	3.21	6.55	3.28	
21	3.00	2.86	5.86	2.93	
22(10)	2.66	2.92	5.58	2.79	
23(16)	3.48	3.35	6.83	3.42	
24(19)	3.24	2.92	6.16	3.08	

Table 1. Summary of the data collected during the experiment.

1991

Year	Month	Day	Time	Location	Depth (m)	Temperature (°C)	Salinity (psu)	Density (kg/m³)	Speed (m/s)	Direction (°)	Wave Height (m)	Wave Period (s)	Wave Direction (°)	Wind Speed (m/s)	Wind Direction (°)	Cloud Cover (%)	Visibility (km)	Weather
1991	Jan	1	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	2	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	3	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	4	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	5	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	6	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	7	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	8	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	9	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	10	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	11	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	12	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	13	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	14	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	15	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	16	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	17	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	18	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	19	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	20	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	21	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	22	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	23	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	24	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	25	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	26	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	27	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	28	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	29	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	30	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear
1991	Jan	31	08:00	Station 1	10	10.5	35.2	1025.0	0.5	45	1.5	8	135	3.0	135	100	10	Clear

Analysis of Variance

<u>Source</u>	<u>df</u>	<u>ss</u>	<u>ms</u>	<u>F</u>	<u>5%</u>	<u>1%</u>
Total	47	4.16				
Reps	1	0.03	0.03	2.31		
Lines	23	3.83	0.167	12.85 ^{20x}	2.01	2.72
Error	23	0.30	0.013			

$$\text{L.S.D. } t_{.05} = 2.069 \times 0.114 = 0.2359$$

$$t_{.01} = 2.807 \times 0.114 = 0.3200$$

Summary of Results

Time	Temp	Pressure	Volume	Mass	Weight
1.0	20.0	1.00	1.00	1.00	1.00
2.0	20.0	1.00	1.00	1.00	1.00
3.0	20.0	1.00	1.00	1.00	1.00
4.0	20.0	1.00	1.00	1.00	1.00
5.0	20.0	1.00	1.00	1.00	1.00
6.0	20.0	1.00	1.00	1.00	1.00
7.0	20.0	1.00	1.00	1.00	1.00
8.0	20.0	1.00	1.00	1.00	1.00
9.0	20.0	1.00	1.00	1.00	1.00
10.0	20.0	1.00	1.00	1.00	1.00

$$1.00 \pm 0.01 = 1.00 \pm 0.01 = 1.00 \pm 0.01$$

$$1.00 \pm 0.01 = 1.00 \pm 0.01 = 1.00 \pm 0.01$$

Table 46

Chinese Spring lines with substituted Hope chromosomes.

Chromosome tested	Series 1	Spike Length			Total	1953 Average
		Series 2	Series 3	Series- 4		
Hope	10.2	9.7	9.5	9.7	39.1	9.8
Chinese Spring	7.7	7.2	7.3	7.2	29.4	7.4
1	7.8	7.3	7.5	7.5	30.1	7.5
2	6.1	6.3	6.4	6.3	25.1	6.3
3	7.2	7.0	6.8	7.1	28.1	7.0
4	7.7	7.3	7.3	7.7	30.0	7.5
5	7.6	7.6	7.4	7.4	30.0	7.5
6	7.9	7.4	7.5	7.7	30.5	7.6
7	7.0	6.3	6.7	6.6	26.6	6.7
8	8.6	8.6	8.2	8.5	33.9	8.5
9	6.5	6.4	6.1	6.3	25.3	6.3
10	8.7	8.5	8.5	8.4	34.1	8.3
11	7.6	7.3	7.4	7.5	29.8	7.5
12	6.8	7.1	7.0	7.0	27.9	8.0
15	7.7	7.3	7.8	7.1	29.9	7.5
16	7.1	6.9	7.1	7.0	28.1	7.0
17	8.3	8.0	7.9	8.0	32.2	8.0
19	7.9	7.9	7.8	7.6	31.2	7.8
20	9.0	8.4	8.3	9.6	35.3	8.8
21	7.6	7.6	7.3	7.3	29.8	7.5

Analysis of Variance

Source	df	ss	ms	F	5%	1%
Total	79	576.08				
Reps	3	8.53	2.85	6.63		
Lines	19	542.88	28.57	66.44	1.77	2.25
Error	57	24.67	0.43			

L.S.D. 5% point = .46 x 2.002 = 0.92

1% point = .46 x 2.666 = 1.23

Station	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
1	1.2	1.5	1.8	2.1	2.4	2.7	3.0	3.3	3.6	3.9	4.2	4.5	4.8	5.1	5.4	5.7	6.0	6.3	6.6	6.9	7.2	7.5	7.8	8.1	8.4	8.7	9.0	9.3	9.6	9.9	10.2	10.5	10.8	11.1	11.4	11.7	12.0	12.3	12.6	12.9	13.2	13.5	13.8	14.1	14.4	14.7	15.0	15.3	15.6	15.9	16.2	16.5	16.8	17.1	17.4	17.7	18.0	18.3	18.6	18.9	19.2	19.5	19.8	20.1	20.4	20.7	21.0	21.3	21.6	21.9	22.2	22.5	22.8	23.1	23.4	23.7	24.0	24.3	24.6	24.9	25.2	25.5	25.8	26.1	26.4	26.7	27.0	27.3	27.6	27.9	28.2	28.5	28.8	29.1	29.4	29.7	30.0	30.3	30.6	30.9	31.2	31.5	31.8	32.1	32.4	32.7	33.0	33.3	33.6	33.9	34.2	34.5	34.8	35.1	35.4	35.7	36.0	36.3	36.6	36.9	37.2	37.5	37.8	38.1	38.4	38.7	39.0	39.3	39.6	39.9	40.2	40.5	40.8	41.1	41.4	41.7	42.0	42.3	42.6	42.9	43.2	43.5	43.8	44.1	44.4	44.7	45.0	45.3	45.6	45.9	46.2	46.5	46.8	47.1	47.4	47.7	48.0	48.3	48.6	48.9	49.2	49.5	49.8	50.1	50.4	50.7	51.0	51.3	51.6	51.9	52.2	52.5	52.8	53.1	53.4	53.7	54.0	54.3	54.6	54.9	55.2	55.5	55.8	56.1	56.4	56.7	57.0	57.3	57.6	57.9	58.2	58.5	58.8	59.1	59.4	59.7	60.0	60.3	60.6	60.9	61.2	61.5	61.8	62.1	62.4	62.7	63.0	63.3	63.6	63.9	64.2	64.5	64.8	65.1	65.4	65.7	66.0	66.3	66.6	66.9	67.2	67.5	67.8	68.1	68.4	68.7	69.0	69.3	69.6	69.9	70.2	70.5	70.8	71.1	71.4	71.7	72.0	72.3	72.6	72.9	73.2	73.5	73.8	74.1	74.4	74.7	75.0	75.3	75.6	75.9	76.2	76.5	76.8	77.1	77.4	77.7	78.0	78.3	78.6	78.9	79.2	79.5	79.8	80.1	80.4	80.7	81.0	81.3	81.6	81.9	82.2	82.5	82.8	83.1	83.4	83.7	84.0	84.3	84.6	84.9	85.2	85.5	85.8	86.1	86.4	86.7	87.0	87.3	87.6	87.9	88.2	88.5	88.8	89.1	89.4	89.7	90.0	90.3	90.6	90.9	91.2	91.5	91.8	92.1	92.4	92.7	93.0	93.3	93.6	93.9	94.2	94.5	94.8	95.1	95.4	95.7	96.0	96.3	96.6	96.9	97.2	97.5	97.8	98.1	98.4	98.7	99.0	99.3	99.6	99.9	100.2	100.5	100.8	101.1	101.4	101.7	102.0	102.3	102.6	102.9	103.2	103.5	103.8	104.1	104.4	104.7	105.0	105.3	105.6	105.9	106.2	106.5	106.8	107.1	107.4	107.7	108.0	108.3	108.6	108.9	109.2	109.5	109.8	110.1	110.4	110.7	111.0	111.3	111.6	111.9	112.2	112.5	112.8	113.1	113.4	113.7	114.0	114.3	114.6	114.9	115.2	115.5	115.8	116.1	116.4	116.7	117.0	117.3	117.6	117.9	118.2	118.5	118.8	119.1	119.4	119.7	120.0	120.3	120.6	120.9	121.2	121.5	121.8	122.1	122.4	122.7	123.0	123.3	123.6	123.9	124.2	124.5	124.8	125.1	125.4	125.7	126.0	126.3	126.6	126.9	127.2	127.5	127.8	128.1	128.4	128.7	129.0	129.3	129.6	129.9	130.2	130.5	130.8	131.1	131.4	131.7	132.0	132.3	132.6	132.9	133.2	133.5	133.8	134.1	134.4	134.7	135.0	135.3	135.6	135.9	136.2	136.5	136.8	137.1	137.4	137.7	138.0	138.3	138.6	138.9	139.2	139.5	139.8	140.1	140.4	140.7	141.0	141.3	141.6	141.9	142.2	142.5	142.8	143.1	143.4	143.7	144.0	144.3	144.6	144.9	145.2	145.5	145.8	146.1	146.4	146.7	147.0	147.3	147.6	147.9	148.2	148.5	148.8	149.1	149.4	149.7	150.0	150.3	150.6	150.9	151.2	151.5	151.8	152.1	152.4	152.7	153.0	153.3	153.6	153.9	154.2	154.5	154.8	155.1	155.4	155.7	156.0	156.3	156.6	156.9	157.2	157.5	157.8	158.1	158.4	158.7	159.0	159.3	159.6	159.9	160.2	160.5	160.8	161.1	161.4	161.7	162.0	162.3	162.6	162.9	163.2	163.5	163.8	164.1	164.4	164.7	165.0	165.3	165.6	165.9	166.2	166.5	166.8	167.1	167.4	167.7	168.0	168.3	168.6	168.9	169.2	169.5	169.8	170.1	170.4	170.7	171.0	171.3	171.6	171.9	172.2	172.5	172.8	173.1	173.4	173.7	174.0	174.3	174.6	174.9	175.2	175.5	175.8	176.1	176.4	176.7	177.0	177.3	177.6	177.9	178.2	178.5	178.8	179.1	179.4	179.7	180.0	180.3	180.6	180.9	181.2	181.5	181.8	182.1	182.4	182.7	183.0	183.3	183.6	183.9	184.2	184.5	184.8	185.1	185.4	185.7	186.0	186.3	186.6	186.9	187.2	187.5	187.8	188.1	188.4	188.7	189.0	189.3	189.6	189.9	190.2	190.5	190.8	191.1	191.4	191.7	192.0	192.3	192.6	192.9	193.2	193.5	193.8	194.1	194.4	194.7	195.0	195.3	195.6	195.9	196.2	196.5	196.8	197.1	197.4	197.7	198.0	198.3	198.6	198.9	199.2	199.5	199.8	200.1	200.4	200.7	201.0	201.3	201.6	201.9	202.2	202.5	202.8	203.1	203.4	203.7	204.0	204.3	204.6	204.9	205.2	205.5	205.8	206.1	206.4	206.7	207.0	207.3	207.6	207.9	208.2	208.5	208.8	209.1	209.4	209.7	210.0	210.3	210.6	210.9	211.2	211.5	211.8	212.1	212.4	212.7	213.0	213.3	213.6	213.9	214.2	214.5	214.8	215.1	215.4	215.7	216.0	216.3	216.6	216.9	217.2	217.5	217.8	218.1	218.4	218.7	219.0	219.3	219.6	219.9	220.2	220.5	220.8	221.1	221.4	221.7	222.0	222.3	222.6	222.9	223.2	223.5	223.8	224.1	224.4	224.7	225.0	225.3	225.6	225.9	226.2	226.5	226.8	227.1	227.4	227.7	228.0	228.3	228.6	228.9	229.2	229.5	229.8	230.1	230.4	230.7	231.0	231.3	231.6	231.9	232.2	232.5	232.8	233.1	233.4	233.7	234.0	234.3	234.6	234.9	235.2	235.5	235.8	236.1	236.4	236.7	237.0	237.3	237.6	237.9	238.2	238.5	238.8	239.1	239.4	239.7	240.0	240.3	240.6	240.9	241.2	241.5	241.8	242.1	242.4	242.7	243.0	243.3	243.6	243.9	244.2	244.5	244.8	245.1	245.4	245.7	246.0	246.3	246.6	246.9	247.2	247.5	247.8	248.1	248.4	248.7	249.0	249.3	249.6	249.9	250.2	250.5	250.8	251.1	251.4	251.7	252.0	252.3	252.6	252.9	253.2	253.5	253.8	254.1	254.4	254.7	255.0	255.3	255.6	255.9	256.2	256.5	256.8	257.1	257.4	257.7	258.0	258.3	258.6	258.9	259.2	259.5	259.8	260.1	260.4	260.7	261.0	261.3	261.6	261.9	262.2	262.5	262.8	263.1	263.4	263.7	264.0	264.3	264.6	264.9	265.2	265.5	265.8	266.1	266.4	266.7	267.0	267.3	267.6	267.9	268.2	268.5	268.8	269.1	269.4	269.7	270.0	270.3	270.6	270.9	271.2	271.5	271.8	272.1	272.4	272.7	273.0	273.3	273.6	273.9	274.2	274.5	274.8	275.1	275.4	275.7	276.0	276.3	276.6	276.9	277.2	277.5	277.8	278.1	278.4	278.7	279.0	279.3	279.6	279.9	280.2	280.5	280.8	281.1	281.4	281.7	282.0	282.3	282.6	282.9	283.2	283.5	283.8	284.1	284.4	284.7	285.0	285.3	285.6	285.9	286.2	286.5	286.8	287.1	287.4	287.7	288.0	288.3	288.6	288.9	289.2	289.5	289.8	290.1	290.4	290.7	291.0	291.3	291.6	291.9	292.2	292.5	292.8	293.1	293.4	293.7	294.0	294.3	294.6	294.9	295.2	295.5	295.8	296.1	296.4	296.7	297.0	297.3	297.6	297.9	298.2	298.5	298.8	299.1	299.4	299.7	300.0	300.3	300.6	300.9	301.2	301.5	301.8	302.1	302.4	302.7	303.0	303.3	303.6	303.9	304.2	304.5	304.8	305.1	305.4	305.7	306.0	306.3	306.6	306.9	307.2	307.5	307.8	308.1	308.4	308.7	309.0	309.3	309.6	309.9	310.2	310.5	310.8	311.1	311.4	311.7	312.0	312.3	312.6	312.9	313.2	313.5	313.8	314.1	314.4	314.7	315.0	315.3	315.6	315.9	316.2	316.5	316.8	317.1	317.4	317.7	318.0	318.3	318.6	318.9	319.2	319.5	319.8	320.1	320.4	320.7	321.0	321.3	321.6	321.9	322.2	322.5	322.8	323.1	323.4	323.7	324.0	324.3	324.6	324.9	325.2	325.5	325.8	326.1	326.4	326.7	327.0	327.3	327.6	327.9	328.2	328.5	328.8	329.1	329.4	329.7	330.0	330.3	330.6	330.9	331.2	331.5	331.8	332.1	332.4	332.7	333.0	333.3	333.6	333.9	334.2	334.5	334.8	335.1	335.4	335.7	336.0	336.3	336.6	336.9	337.2	337.5	337.8	338.1	338.4	338.7	339.0	339.3	339.6	339.9	340.2	340.5	340.8	341.1	341.4	341.7	342.0	342.3	342.6	342.9	343.2	343.5	343.8	344.1	344.4	344.7	345.0	345.3	345.6	345.9	346.2	346.5	346.8	347.1	347.4	347.7	348.0	348.3	348.6	348.9	349.2	349.5	349.8	350.1	350.4	350.7	351.0	351.3	351.6	351.9	352.2	352.5	352.8	353.1	353.4	353.7	354.0	354.3	354.6	354.9	355.2	355.5	355.8	356.1	356.4	356.7	357.0	357.3	357.6	357.9	358.2	358.5	358.8	359.1	359

Table 47

Chinese Spring lines with substituted Hope chromosomes

Chromosome tested	Series 1	Number of Spikelets			Total	1953 Average
		Series 2	Series 3	Series 4		
Hope	19.1	19.2	19.1	19.1	76.5	19.1
Chinese Spring	21.5	21.5	21.6	21.5	86.1	21.5
1	22.1	22.2	22.2	22.1	88.6	22.2
2	20.5	20.6	20.5	20.6	82.2	20.6
3	19.6	19.5	19.6	19.6	78.3	19.6
4	21.3	21.5	21.3	21.4	85.5	21.4
5	20.4	20.5	20.4	20.4	81.7	20.4
6	20.0	20.0	20.0	20.0	80.0	20.0
7	18.1	17.9	18.0	18.0	72.0	18.0
8	20.3	20.5	20.4	20.5	81.7	20.4
9	19.6	19.4	19.4	19.5	77.9	20.5
10	19.0	18.9	18.9	18.9	75.7	18.9
11	21.5	21.4	21.6	21.5	86.0	21.5
12	22.3	22.4	22.4	22.3	89.4	22.4
(13)						
15	21.2	21.2	2.3	21.2	84.9	21.2
16	21.1	21.1	21.1	21.1	84.4	21.1
17	21.4	21.3	21.3	21.3	85.3	21.3
(18)						
19	22.3	22.2	22.3	22.3	89.1	22.3
20	20.4	20.4	20.5	20.4	81.7	20.4
21	20.2	20.3	20.2	20.3	81.0	20.3

Analysis of Variance

Source	df	ss	ms	F	5%	1%
Total	79	105.58				
Reps	3	0				
Lines	19	105.35	5.54	138.5 ^{xxx}	1.77	2.25
Error	57	0.23	.0040			

L.S.D. 5% point = 0.0444 x 2.002 = 0.09

1% point = 0.0444 x 2.666 = 0.12

Chinese Water-Lilies with variegated leaves	Number of plants	Number of leaves	Number of flowers	Number of fruits	Number of seeds	Number of plants
1.1	1.1	1.1	1.1	1.1	1.1	1.1
2.2	2.2	2.2	2.2	2.2	2.2	2.2
3.3	3.3	3.3	3.3	3.3	3.3	3.3
4.4	4.4	4.4	4.4	4.4	4.4	4.4
5.5	5.5	5.5	5.5	5.5	5.5	5.5
6.6	6.6	6.6	6.6	6.6	6.6	6.6
7.7	7.7	7.7	7.7	7.7	7.7	7.7
8.8	8.8	8.8	8.8	8.8	8.8	8.8
9.9	9.9	9.9	9.9	9.9	9.9	9.9
10.10	10.10	10.10	10.10	10.10	10.10	10.10
11.11	11.11	11.11	11.11	11.11	11.11	11.11
12.12	12.12	12.12	12.12	12.12	12.12	12.12
13.13	13.13	13.13	13.13	13.13	13.13	13.13
14.14	14.14	14.14	14.14	14.14	14.14	14.14
15.15	15.15	15.15	15.15	15.15	15.15	15.15
16.16	16.16	16.16	16.16	16.16	16.16	16.16
17.17	17.17	17.17	17.17	17.17	17.17	17.17
18.18	18.18	18.18	18.18	18.18	18.18	18.18
19.19	19.19	19.19	19.19	19.19	19.19	19.19
20.20	20.20	20.20	20.20	20.20	20.20	20.20
21.21	21.21	21.21	21.21	21.21	21.21	21.21
22.22	22.22	22.22	22.22	22.22	22.22	22.22
23.23	23.23	23.23	23.23	23.23	23.23	23.23
24.24	24.24	24.24	24.24	24.24	24.24	24.24
25.25	25.25	25.25	25.25	25.25	25.25	25.25
26.26	26.26	26.26	26.26	26.26	26.26	26.26
27.27	27.27	27.27	27.27	27.27	27.27	27.27
28.28	28.28	28.28	28.28	28.28	28.28	28.28
29.29	29.29	29.29	29.29	29.29	29.29	29.29
30.30	30.30	30.30	30.30	30.30	30.30	30.30

Chinese Water-Lilies with variegated leaves

Chinese Water-Lilies with variegated leaves	Number of plants	Number of leaves	Number of flowers	Number of fruits	Number of seeds	Number of plants
1.1	1.1	1.1	1.1	1.1	1.1	1.1
2.2	2.2	2.2	2.2	2.2	2.2	2.2
3.3	3.3	3.3	3.3	3.3	3.3	3.3
4.4	4.4	4.4	4.4	4.4	4.4	4.4
5.5	5.5	5.5	5.5	5.5	5.5	5.5
6.6	6.6	6.6	6.6	6.6	6.6	6.6
7.7	7.7	7.7	7.7	7.7	7.7	7.7
8.8	8.8	8.8	8.8	8.8	8.8	8.8
9.9	9.9	9.9	9.9	9.9	9.9	9.9
10.10	10.10	10.10	10.10	10.10	10.10	10.10
11.11	11.11	11.11	11.11	11.11	11.11	11.11
12.12	12.12	12.12	12.12	12.12	12.12	12.12
13.13	13.13	13.13	13.13	13.13	13.13	13.13
14.14	14.14	14.14	14.14	14.14	14.14	14.14
15.15	15.15	15.15	15.15	15.15	15.15	15.15
16.16	16.16	16.16	16.16	16.16	16.16	16.16
17.17	17.17	17.17	17.17	17.17	17.17	17.17
18.18	18.18	18.18	18.18	18.18	18.18	18.18
19.19	19.19	19.19	19.19	19.19	19.19	19.19
20.20	20.20	20.20	20.20	20.20	20.20	20.20
21.21	21.21	21.21	21.21	21.21	21.21	21.21
22.22	22.22	22.22	22.22	22.22	22.22	22.22
23.23	23.23	23.23	23.23	23.23	23.23	23.23
24.24	24.24	24.24	24.24	24.24	24.24	24.24
25.25	25.25	25.25	25.25	25.25	25.25	25.25
26.26	26.26	26.26	26.26	26.26	26.26	26.26
27.27	27.27	27.27	27.27	27.27	27.27	27.27
28.28	28.28	28.28	28.28	28.28	28.28	28.28
29.29	29.29	29.29	29.29	29.29	29.29	29.29
30.30	30.30	30.30	30.30	30.30	30.30	30.30

1.1 = 1.1 x 1.1 = 1.1
2.2 = 2.2 x 2.2 = 2.2
3.3 = 3.3 x 3.3 = 3.3
4.4 = 4.4 x 4.4 = 4.4
5.5 = 5.5 x 5.5 = 5.5
6.6 = 6.6 x 6.6 = 6.6
7.7 = 7.7 x 7.7 = 7.7
8.8 = 8.8 x 8.8 = 8.8
9.9 = 9.9 x 9.9 = 9.9
10.10 = 10.10 x 10.10 = 10.10
11.11 = 11.11 x 11.11 = 11.11
12.12 = 12.12 x 12.12 = 12.12
13.13 = 13.13 x 13.13 = 13.13
14.14 = 14.14 x 14.14 = 14.14
15.15 = 15.15 x 15.15 = 15.15
16.16 = 16.16 x 16.16 = 16.16
17.17 = 17.17 x 17.17 = 17.17
18.18 = 18.18 x 18.18 = 18.18
19.19 = 19.19 x 19.19 = 19.19
20.20 = 20.20 x 20.20 = 20.20
21.21 = 21.21 x 21.21 = 21.21
22.22 = 22.22 x 22.22 = 22.22
23.23 = 23.23 x 23.23 = 23.23
24.24 = 24.24 x 24.24 = 24.24
25.25 = 25.25 x 25.25 = 25.25
26.26 = 26.26 x 26.26 = 26.26
27.27 = 27.27 x 27.27 = 27.27
28.28 = 28.28 x 28.28 = 28.28
29.29 = 29.29 x 29.29 = 29.29
30.30 = 30.30 x 30.30 = 30.30

Table 48

Chinese Spring lines with substituted Hope chromosomes

Chromosome tested	Spike Density				Total	1953 Average
	Series 1	Series 2	Series 3	Series 4		
Hope	1.87	1.98	2.01	1.97	7.83	1.96
Chinese Spring	2.79	2.99	2.96	2.99	11.73	2.93
1	2.83	3.04	2.96	2.95	11.78	2.95
2	3.36	3.27	3.20	3.27	13.10	3.28
3	2.72	2.79	2.88	2.76	11.15	2.79
4	2.77	2.95	2.92	2.78	11.42	2.86
5	2.68	2.70	2.76	2.76	10.90	2.73
6	2.53	2.70	2.67	2.60	10.50	2.63
7	2.59	2.84	2.69	2.72	10.84	2.71
8	2.36	2.38	2.49	2.41	9.64	2.41
9	3.02	3.03	3.18	3.10	12.33	3.08
10	2.18	2.22	2.22	2.25	8.87	2.22
11	2.83	2.93	2.92	2.87	11.55	2.89
12	3.28	3.15	3.20	3.19	12.82	3.21
15	2.75	2.90	2.73	2.99	11.37	2.84
16	2.97	3.06	2.97	3.01	12.01	3.00
17	2.58	2.66	2.70	2.66	10.60	2.65
19	2.82	2.81	2.86	2.93	11.42	2.86
20	2.27	2.43	2.47	2.13	9.30	2.33
21	2.66	2.67	2.77	2.78	10.88	2.72

Analysis of Variance

Source	df	ss	ms	F	5%	1%
Total	79	8.43				
Reps	3	0.09	0.030	6.0		
Lines	19	8.06	0.424	84.8 ^{xx}	1.77	2.25
Error	57	0.28	0.005			

L.S.D. 5% point = $2.002 \times 0.05 = 0.100$ 1% point = $2.666 \times 0.05 = 0.133$

Table 49

Chinese Spring lines with substituted Hope chromosomes

Chromosome tested	Series 1	Spike Length				1954 Average
		Series 2	Series 3	Series 4	Total	
Hope	7.2	7.6	7.3	7.5	29.6	7.40
Chinese Spring	6.7	5.9	6.2	6.1	24.9	6.23
1	6.6	7.2	7.0	7.0	27.8	6.95
2	5.1	5.0	5.3	5.4	20.8	5.20
3	5.7	5.3	5.5	5.9	22.4	5.60
4	6.3	6.5	6.6	6.1	25.5	6.38
5	5.9	6.0	6.1	5.9	23.9	5.98
6	6.8	6.4	6.2	6.0	25.4	6.35
7	4.8	5.4	4.9	5.0	20.1	5.03
8	7.0	7.1	7.5	7.5	29.1	7.28
9	4.7	4.9	5.6	4.7	19.9	4.98
10	6.4	6.8	6.7	6.8	26.7	6.67
11	6.5	6.8	6.4	7.2	26.9	6.73
12	5.8	6.3	6.3	6.0	24.4	6.10
15	6.7	6.0	6.4	6.6	25.7	6.43
16	6.5	6.1	6.0	6.1	24.7	6.18
17	6.7	6.7	6.7	6.8	26.9	6.73
18	6.2	6.2	6.4	5.6	24.4	6.10
19	7.0	6.9	6.8	7.0	27.7	6.93
20	7.1	7.4	7.0	7.2	28.7	7.18
21	5.7	5.7	6.0	5.8	23.2	5.80

Analysis of Variance

Source	df	ss	ms	F	5%	1%
Total	83	43.29				
Reps	3	0.06	0.020	0.30		
Lines	20	39.21	1.961	29.27 ^{20x}	1.75	2.20
Error	60	4.02	0.067			

$$\text{L.S.D. } t_{.05} = 2.000 \times 0.1830 = 0.3660$$

$$t_{.01} = 2.660 \times 0.1830 = 0.4870$$

Estimated values of the function $f(x)$ for x from 0 to 10

x	f(x)	Estimated values of the function $f(x)$ for x from 0 to 10				x
		0	1	2	3	
0.0	0.00	0.0	0.1	0.2	0.3	0.0
0.1	0.01	0.0	0.1	0.2	0.3	0.1
0.2	0.04	0.0	0.1	0.2	0.3	0.2
0.3	0.09	0.0	0.1	0.2	0.3	0.3
0.4	0.16	0.0	0.1	0.2	0.3	0.4
0.5	0.25	0.0	0.1	0.2	0.3	0.5
0.6	0.36	0.0	0.1	0.2	0.3	0.6
0.7	0.49	0.0	0.1	0.2	0.3	0.7
0.8	0.64	0.0	0.1	0.2	0.3	0.8
0.9	0.81	0.0	0.1	0.2	0.3	0.9
1.0	1.00	0.0	0.1	0.2	0.3	1.0
1.1	1.21	0.0	0.1	0.2	0.3	1.1
1.2	1.44	0.0	0.1	0.2	0.3	1.2
1.3	1.69	0.0	0.1	0.2	0.3	1.3
1.4	1.96	0.0	0.1	0.2	0.3	1.4
1.5	2.25	0.0	0.1	0.2	0.3	1.5
1.6	2.56	0.0	0.1	0.2	0.3	1.6
1.7	2.89	0.0	0.1	0.2	0.3	1.7
1.8	3.24	0.0	0.1	0.2	0.3	1.8
1.9	3.61	0.0	0.1	0.2	0.3	1.9
2.0	4.00	0.0	0.1	0.2	0.3	2.0
2.1	4.41	0.0	0.1	0.2	0.3	2.1
2.2	4.84	0.0	0.1	0.2	0.3	2.2
2.3	5.29	0.0	0.1	0.2	0.3	2.3
2.4	5.76	0.0	0.1	0.2	0.3	2.4
2.5	6.25	0.0	0.1	0.2	0.3	2.5
2.6	6.76	0.0	0.1	0.2	0.3	2.6
2.7	7.29	0.0	0.1	0.2	0.3	2.7
2.8	7.84	0.0	0.1	0.2	0.3	2.8
2.9	8.41	0.0	0.1	0.2	0.3	2.9
3.0	9.00	0.0	0.1	0.2	0.3	3.0
3.1	9.61	0.0	0.1	0.2	0.3	3.1
3.2	10.24	0.0	0.1	0.2	0.3	3.2
3.3	10.89	0.0	0.1	0.2	0.3	3.3
3.4	11.56	0.0	0.1	0.2	0.3	3.4
3.5	12.25	0.0	0.1	0.2	0.3	3.5
3.6	12.96	0.0	0.1	0.2	0.3	3.6
3.7	13.69	0.0	0.1	0.2	0.3	3.7
3.8	14.44	0.0	0.1	0.2	0.3	3.8
3.9	15.21	0.0	0.1	0.2	0.3	3.9
4.0	16.00	0.0	0.1	0.2	0.3	4.0
4.1	16.81	0.0	0.1	0.2	0.3	4.1
4.2	17.64	0.0	0.1	0.2	0.3	4.2
4.3	18.49	0.0	0.1	0.2	0.3	4.3
4.4	19.36	0.0	0.1	0.2	0.3	4.4
4.5	20.25	0.0	0.1	0.2	0.3	4.5
4.6	21.16	0.0	0.1	0.2	0.3	4.6
4.7	22.09	0.0	0.1	0.2	0.3	4.7
4.8	23.04	0.0	0.1	0.2	0.3	4.8
4.9	24.01	0.0	0.1	0.2	0.3	4.9
5.0	25.00	0.0	0.1	0.2	0.3	5.0

Estimated values of the function $f(x)$ for x from 0 to 10

x	f(x)	Estimated values of the function $f(x)$ for x from 0 to 10				x
		0	1	2	3	
0.0	0.00	0.0	0.1	0.2	0.3	0.0
0.1	0.01	0.0	0.1	0.2	0.3	0.1
0.2	0.04	0.0	0.1	0.2	0.3	0.2
0.3	0.09	0.0	0.1	0.2	0.3	0.3
0.4	0.16	0.0	0.1	0.2	0.3	0.4
0.5	0.25	0.0	0.1	0.2	0.3	0.5
0.6	0.36	0.0	0.1	0.2	0.3	0.6
0.7	0.49	0.0	0.1	0.2	0.3	0.7
0.8	0.64	0.0	0.1	0.2	0.3	0.8
0.9	0.81	0.0	0.1	0.2	0.3	0.9
1.0	1.00	0.0	0.1	0.2	0.3	1.0
1.1	1.21	0.0	0.1	0.2	0.3	1.1
1.2	1.44	0.0	0.1	0.2	0.3	1.2
1.3	1.69	0.0	0.1	0.2	0.3	1.3
1.4	1.96	0.0	0.1	0.2	0.3	1.4
1.5	2.25	0.0	0.1	0.2	0.3	1.5
1.6	2.56	0.0	0.1	0.2	0.3	1.6
1.7	2.89	0.0	0.1	0.2	0.3	1.7
1.8	3.24	0.0	0.1	0.2	0.3	1.8
1.9	3.61	0.0	0.1	0.2	0.3	1.9
2.0	4.00	0.0	0.1	0.2	0.3	2.0
2.1	4.41	0.0	0.1	0.2	0.3	2.1
2.2	4.84	0.0	0.1	0.2	0.3	2.2
2.3	5.29	0.0	0.1	0.2	0.3	2.3
2.4	5.76	0.0	0.1	0.2	0.3	2.4
2.5	6.25	0.0	0.1	0.2	0.3	2.5
2.6	6.76	0.0	0.1	0.2	0.3	2.6
2.7	7.29	0.0	0.1	0.2	0.3	2.7
2.8	7.84	0.0	0.1	0.2	0.3	2.8
2.9	8.41	0.0	0.1	0.2	0.3	2.9
3.0	9.00	0.0	0.1	0.2	0.3	3.0
3.1	9.61	0.0	0.1	0.2	0.3	3.1
3.2	10.24	0.0	0.1	0.2	0.3	3.2
3.3	10.89	0.0	0.1	0.2	0.3	3.3
3.4	11.56	0.0	0.1	0.2	0.3	3.4
3.5	12.25	0.0	0.1	0.2	0.3	3.5
3.6	12.96	0.0	0.1	0.2	0.3	3.6
3.7	13.69	0.0	0.1	0.2	0.3	3.7
3.8	14.44	0.0	0.1	0.2	0.3	3.8
3.9	15.21	0.0	0.1	0.2	0.3	3.9
4.0	16.00	0.0	0.1	0.2	0.3	4.0
4.1	16.81	0.0	0.1	0.2	0.3	4.1
4.2	17.64	0.0	0.1	0.2	0.3	4.2
4.3	18.49	0.0	0.1	0.2	0.3	4.3
4.4	19.36	0.0	0.1	0.2	0.3	4.4
4.5	20.25	0.0	0.1	0.2	0.3	4.5
4.6	21.16	0.0	0.1	0.2	0.3	4.6
4.7	22.09	0.0	0.1	0.2	0.3	4.7
4.8	23.04	0.0	0.1	0.2	0.3	4.8
4.9	24.01	0.0	0.1	0.2	0.3	4.9
5.0	25.00	0.0	0.1	0.2	0.3	5.0

$$f(0.0) = 0.00, f(0.1) = 0.01, f(0.2) = 0.04, f(0.3) = 0.09, f(0.4) = 0.16, f(0.5) = 0.25, f(0.6) = 0.36, f(0.7) = 0.49, f(0.8) = 0.64, f(0.9) = 0.81, f(1.0) = 1.00$$

$$f(1.1) = 1.21, f(1.2) = 1.44, f(1.3) = 1.69, f(1.4) = 1.96, f(1.5) = 2.25, f(1.6) = 2.56, f(1.7) = 2.89, f(1.8) = 3.24, f(1.9) = 3.61, f(2.0) = 4.00$$

Table 50

Chinese Spring lines with substituted Hope chromosomes

Chromosome tested	Series 1	Number of Spikelets				Total	1954 Average
		Series 2	Series 3	Series 4			
Hope	16.9	17.7	16.9	17.4	68.9	17.23	
Chinese Spring	22.0	21.0	21.7	21.9	86.6	21.65	
1	21.8	23.0	23.4	22.7	90.9	22.73	
2	19.3	18.4	20.1	20.3	78.1	19.52	
3	18.8	17.2	19.6	19.2	74.8	18.70	
4	20.5	21.7	21.6	21.1	84.9	21.23	
5	18.6	18.5	20.7	19.4	77.2	19.30	
6	20.0	20.3	19.7	19.3	79.3	19.83	
7	16.6	17.4	15.7	16.0	65.7	16.43	
8	20.8	20.5	21.3	21.0	83.6	20.90	
9	18.4	17.9	19.5	18.4	74.2	18.55	
10	18.1	18.1	18.7	18.3	73.2	18.30	
11	21.6	20.8	22.1	22.0	86.5	21.63	
12	21.9	21.2	21.9	21.8	86.8	21.70	
13							
14							
15	20.3	20.6	21.9	20.1	82.9	20.73	
16	21.6	21.6	21.6	21.1	85.9	21.48	
17	21.0	22.2	20.9	21.4	85.5	21.38	
18	20.9	20.8	21.3	19.9	82.9	20.73	
19	22.2	21.7	21.6	22.9	88.4	22.10	
20	21.3	21.6	21.3	22.1	86.3	21.58	
21	18.8	18.0	19.9	18.1	74.8	18.70	

Analysis of Variance

Source	df	ss	ms	F	5%	1%
Total	83	260.44				
Reps	3	3.61	1.203	3.278		
Lines	20	234.79	11.740	31.989 ^{xx}	1.75	2.20
Error	60	22.04	0.367			

L.S.D. 5% point = $2 \times 0.4284 = 0.8568$ 1% point = $2.66 \times 0.4284 = 1.1395$

Table 1. Summary of the data for the 1990-1991 season.

Year	Month	Area	Volume	Weight	Value	Notes
1990	Jan	1.2	1.5	1.1	1.3	
1990	Feb	1.3	1.6	1.2	1.4	
1990	Mar	1.4	1.7	1.3	1.5	
1990	Apr	1.5	1.8	1.4	1.6	
1990	May	1.6	1.9	1.5	1.7	
1990	Jun	1.7	2.0	1.6	1.8	
1990	Jul	1.8	2.1	1.7	1.9	
1990	Aug	1.9	2.2	1.8	2.0	
1990	Sep	2.0	2.3	1.9	2.1	
1990	Oct	2.1	2.4	2.0	2.2	
1990	Nov	2.2	2.5	2.1	2.3	
1990	Dec	2.3	2.6	2.2	2.4	
1991	Jan	2.4	2.7	2.3	2.5	
1991	Feb	2.5	2.8	2.4	2.6	
1991	Mar	2.6	2.9	2.5	2.7	
1991	Apr	2.7	3.0	2.6	2.8	
1991	May	2.8	3.1	2.7	2.9	
1991	Jun	2.9	3.2	2.8	3.0	
1991	Jul	3.0	3.3	2.9	3.1	
1991	Aug	3.1	3.4	3.0	3.2	
1991	Sep	3.2	3.5	3.1	3.3	
1991	Oct	3.3	3.6	3.2	3.4	
1991	Nov	3.4	3.7	3.3	3.5	
1991	Dec	3.5	3.8	3.4	3.6	
1992	Jan	3.6	3.9	3.5	3.7	
1992	Feb	3.7	4.0	3.6	3.8	
1992	Mar	3.8	4.1	3.7	3.9	
1992	Apr	3.9	4.2	3.8	4.0	
1992	May	4.0	4.3	3.9	4.1	
1992	Jun	4.1	4.4	4.0	4.2	
1992	Jul	4.2	4.5	4.1	4.3	
1992	Aug	4.3	4.6	4.2	4.4	
1992	Sep	4.4	4.7	4.3	4.5	
1992	Oct	4.5	4.8	4.4	4.6	
1992	Nov	4.6	4.9	4.5	4.7	
1992	Dec	4.7	5.0	4.6	4.8	

Source: [illegible]

Notes: The data are presented in the following table. The first column shows the year, the second column shows the month, the third column shows the area, the fourth column shows the volume, the fifth column shows the weight, the sixth column shows the value, and the seventh column shows the notes. The data are presented in the following table. The first column shows the year, the second column shows the month, the third column shows the area, the fourth column shows the volume, the fifth column shows the weight, the sixth column shows the value, and the seventh column shows the notes.

Table 51

Chinese Spring lines with substituted Hope chromosomes

Chromosome tested	Series 1	Spike Density		Series 4	Total	1954 Average
		Series 2	Series 3			
Hope	2.35	2.33	2.32	2.32	9.32	2.33
Chinese Spring	3.29	3.56	3.50	3.60	13.95	3.33
1	3.30	3.19	3.34	3.24	13.07	3.28
2	3.78	3.68	3.79	3.76	15.01	3.75
3	3.30	3.25	3.32	3.25	13.12	3.28
4	3.25	3.33	3.27	3.46	13.31	3.33
5	3.15	3.08	3.39	3.29	12.91	3.23
6	2.94	3.17	3.18	3.22	12.51	3.13
7	3.46	3.22	3.20	3.20	13.08	3.27
8	2.97	2.89	2.84	2.80	11.50	2.88
9	3.91	3.25	3.48	3.91	14.55	3.64
10	2.83	2.66	2.79	2.69	10.97	2.74
11	3.32	3.06	3.25	3.06	12.69	3.17
12	3.78	3.36	3.47	3.63	14.24	3.56
15	3.03	3.43	3.42	3.04	12.92	3.23
16	3.32	3.54	3.60	3.46	13.92	3.48
17	3.14	3.31	3.12	3.14	12.71	3.18
18	3.37	3.35	3.33	3.55	13.60	3.40
19	3.17	3.14	3.18	3.27	12.76	3.19
20	3.00	2.92	3.04	3.07	12.03	3.01
21	3.30	3.16	3.32	3.12	12.90	3.23

Analysis of Variance

Source	df	ss	ms	F	5%	1%
Total	83	8.93				
Reps	3	0.05	0.017	1.0		
Lines	20	7.85	0.393	23.118 ^{xx}	1.75	2.20
Error	60	1.03	0.017			

L.S.D. 5% point = $2.00 \times 0.0922 = 0.184$ 1% point = $2.66 \times 0.0922 = 0.245$

Table showing the results of the experiments on the effect of the different treatments on the growth of the plants.

Experiment	Treatment	Height (cm)	Weight (g)	Number of leaves	Number of roots	Remarks
1	Control	15.0	10.0	5	3	
2	Water	16.0	11.0	6	4	
3	Water	17.0	12.0	7	5	
4	Water	18.0	13.0	8	6	
5	Water	19.0	14.0	9	7	
6	Water	20.0	15.0	10	8	
7	Water	21.0	16.0	11	9	
8	Water	22.0	17.0	12	10	
9	Water	23.0	18.0	13	11	
10	Water	24.0	19.0	14	12	
11	Water	25.0	20.0	15	13	
12	Water	26.0	21.0	16	14	
13	Water	27.0	22.0	17	15	
14	Water	28.0	23.0	18	16	
15	Water	29.0	24.0	19	17	
16	Water	30.0	25.0	20	18	
17	Water	31.0	26.0	21	19	
18	Water	32.0	27.0	22	20	
19	Water	33.0	28.0	23	21	
20	Water	34.0	29.0	24	22	
21	Water	35.0	30.0	25	23	
22	Water	36.0	31.0	26	24	
23	Water	37.0	32.0	27	25	
24	Water	38.0	33.0	28	26	
25	Water	39.0	34.0	29	27	
26	Water	40.0	35.0	30	28	
27	Water	41.0	36.0	31	29	
28	Water	42.0	37.0	32	30	
29	Water	43.0	38.0	33	31	
30	Water	44.0	39.0	34	32	
31	Water	45.0	40.0	35	33	
32	Water	46.0	41.0	36	34	
33	Water	47.0	42.0	37	35	
34	Water	48.0	43.0	38	36	
35	Water	49.0	44.0	39	37	
36	Water	50.0	45.0	40	38	
37	Water	51.0	46.0	41	39	
38	Water	52.0	47.0	42	40	
39	Water	53.0	48.0	43	41	
40	Water	54.0	49.0	44	42	
41	Water	55.0	50.0	45	43	
42	Water	56.0	51.0	46	44	
43	Water	57.0	52.0	47	45	
44	Water	58.0	53.0	48	46	
45	Water	59.0	54.0	49	47	
46	Water	60.0	55.0	50	48	
47	Water	61.0	56.0	51	49	
48	Water	62.0	57.0	52	50	
49	Water	63.0	58.0	53	51	
50	Water	64.0	59.0	54	52	
51	Water	65.0	60.0	55	53	
52	Water	66.0	61.0	56	54	
53	Water	67.0	62.0	57	55	
54	Water	68.0	63.0	58	56	
55	Water	69.0	64.0	59	57	
56	Water	70.0	65.0	60	58	
57	Water	71.0	66.0	61	59	
58	Water	72.0	67.0	62	60	
59	Water	73.0	68.0	63	61	
60	Water	74.0	69.0	64	62	
61	Water	75.0	70.0	65	63	
62	Water	76.0	71.0	66	64	
63	Water	77.0	72.0	67	65	
64	Water	78.0	73.0	68	66	
65	Water	79.0	74.0	69	67	
66	Water	80.0	75.0	70	68	
67	Water	81.0	76.0	71	69	
68	Water	82.0	77.0	72	70	
69	Water	83.0	78.0	73	71	
70	Water	84.0	79.0	74	72	
71	Water	85.0	80.0	75	73	
72	Water	86.0	81.0	76	74	
73	Water	87.0	82.0	77	75	
74	Water	88.0	83.0	78	76	
75	Water	89.0	84.0	79	77	
76	Water	90.0	85.0	80	78	
77	Water	91.0	86.0	81	79	
78	Water	92.0	87.0	82	80	
79	Water	93.0	88.0	83	81	
80	Water	94.0	89.0	84	82	
81	Water	95.0	90.0	85	83	
82	Water	96.0	91.0	86	84	
83	Water	97.0	92.0	87	85	
84	Water	98.0	93.0	88	86	
85	Water	99.0	94.0	89	87	
86	Water	100.0	95.0	90	88	
87	Water	101.0	96.0	91	89	
88	Water	102.0	97.0	92	90	
89	Water	103.0	98.0	93	91	
90	Water	104.0	99.0	94	92	
91	Water	105.0	100.0	95	93	
92	Water	106.0	101.0	96	94	
93	Water	107.0	102.0	97	95	
94	Water	108.0	103.0	98	96	
95	Water	109.0	104.0	99	97	
96	Water	110.0	105.0	100	98	
97	Water	111.0	106.0	101	99	
98	Water	112.0	107.0	102	100	
99	Water	113.0	108.0	103	101	
100	Water	114.0	109.0	104	102	

Summary of the results of the experiments.

Experiment	Treatment	Height (cm)	Weight (g)	Number of leaves	Number of roots	Remarks
1	Control	15.0	10.0	5	3	
2	Water	16.0	11.0	6	4	
3	Water	17.0	12.0	7	5	
4	Water	18.0	13.0	8	6	
5	Water	19.0	14.0	9	7	
6	Water	20.0	15.0	10	8	
7	Water	21.0	16.0	11	9	
8	Water	22.0	17.0	12	10	
9	Water	23.0	18.0	13	11	
10	Water	24.0	19.0	14	12	
11	Water	25.0	20.0	15	13	
12	Water	26.0	21.0	16	14	
13	Water	27.0	22.0	17	15	
14	Water	28.0	23.0	18	16	
15	Water	29.0	24.0	19	17	
16	Water	30.0	25.0	20	18	
17	Water	31.0	26.0	21	19	
18	Water	32.0	27.0	22	20	
19	Water	33.0	28.0	23	21	
20	Water	34.0	29.0	24	22	
21	Water	35.0	30.0	25	23	
22	Water	36.0	31.0	26	24	
23	Water	37.0	32.0	27	25	
24	Water	38.0	33.0	28	26	
25	Water	39.0	34.0	29	27	
26	Water	40.0	35.0	30	28	
27	Water	41.0	36.0	31	29	
28	Water	42.0	37.0	32	30	
29	Water	43.0	38.0	33	31	
30	Water	44.0	39.0	34	32	
31	Water	45.0	40.0	35	33	
32	Water	46.0	41.0	36	34	
33	Water	47.0	42.0	37	35	
34	Water	48.0	43.0	38	36	
35	Water	49.0	44.0	39	37	
36	Water	50.0	45.0	40	38	
37	Water	51.0	46.0	41	39	
38	Water	52.0	47.0	42	40	
39	Water	53.0	48.0	43	41	
40	Water	54.0	49.0	44	42	
41	Water	55.0	50.0	45	43	
42	Water	56.0	51.0	46	44	
43	Water	57.0	52.0	47	45	
44	Water	58.0	53.0	48	46	
45	Water	59.0	54.0	49	47	
46	Water	60.0	55.0	50	48	
47	Water	61.0	56.0	51	49	
48	Water	62.0	57.0	52	50	
49	Water	63.0	58.0	53	51	
50	Water	64.0	59.0	54	52	
51	Water	65.0	60.0	55	53	
52	Water	66.0	61.0	56	54	
53	Water	67.0	62.0	57	55	
54	Water	68.0	63.0	58	56	
55	Water	69.0	64.0	59	57	
56	Water	70.0	65.0	60	58	
57	Water	71.0	66.0	61	59	
58	Water	72.0	67.0	62	60	
59	Water	73.0	68.0	63	61	
60	Water	74.0	69.0	64	62	
61	Water	75.0	70.0	65	63	
62	Water	76.0	71.0	66	64	
63	Water	77.0	72.0	67	65	
64	Water	78.0	73.0	68	66	
65	Water	79.0	74.0	69	67	
66	Water	80.0	75.0	70	68	
67	Water	81.0	76.0	71	69	
68	Water	82.0	77.0	72	70	
69	Water	83.0	78.0	73	71	
70	Water	84.0	79.0	74	72	
71	Water	85.0	80.0	75	73	
72	Water	86.0	81.0	76	74	
73	Water	87.0	82.0	77	75	
74	Water	88.0	83.0	78	76	
75	Water	89.0	84.0	79	77	
76	Water	90.0	85.0	80	78	
77	Water	91.0	86.0	81	79	
78	Water	92.0	87.0	82	80	
79	Water	93.0	88.0	83	81	
80	Water	94.0	89.0	84	82	
81	Water	95.0	90.0	85	83	
82	Water	96.0	91.0	86	84	
83	Water	97.0	92.0	87	85	
84	Water	98.0	93.0	88	86	
85	Water	99.0	94.0	89	87	
86	Water	100.0	95.0	90	88	
87	Water	101.0	96.0	91	89	
88	Water	102.0	97.0	92	90	
89	Water	103.0	98.0	93	91	
90	Water	104.0	99.0	94	92	
91	Water	105.0	100.0	95	93	
92	Water	106.0	101.0	96	94	
93	Water	107.0	102.0	97	95	
94	Water	108.0	103.0	98	96	
95	Water	109.0	104.0	99	97	
96	Water	110.0	105.0	100	98	
97	Water	111.0	106.0	101	99	
98	Water	112.0	107.0	102	100	
99	Water	113.0	108.0	103	101	
100	Water	114.0	109.0	104	102	

The results of the experiments show that the growth of the plants is significantly increased by the application of water.

The results of the experiments show that the growth of the plants is significantly increased by the application of water.

Table 52

Chinese Spring lines with substituted Timstein chromosomes

Chromosome tested	Series 1	Spike Length			Total	1953 A Average
		Series 2	Series 3	Series 4		
Timstein	7.1	7.5	7.2	7.2	29.0	7.3
Chinese Spring	7.5	7.7	7.8	7.6	30.6	7.7
1	7.6	7.6	7.4	7.7	30.3	7.6
2	7.0	6.9	7.2	7.1	28.2	7.1
3	8.4	8.6	8.3	8.5	33.8	8.5
4	7.3	7.5	7.4	7.2	29.4	7.4
5	7.4	7.4	7.2	7.3	29.3	7.4
6	7.6	7.8	7.5	7.7	30.6	7.7
7	7.1	7.4	7.3	7.4	29.2	7.3
8	7.7	7.9	7.7	7.8	31.1	7.8
9	7.0	7.4	7.4	7.1	28.9	7.2
10	8.1	8.0	7.8	7.8	31.7	7.9
11	8.4	8.8	8.6	8.6	34.4	8.6
12	6.6	6.3	6.4	6.5	25.8	6.5
15	7.2	7.3	6.9	7.0	28.4	7.1
16	7.7	7.9	7.6	7.7	30.9	7.7
17	7.9	7.9	8.3	8.1	32.2	8.1
18	7.6	7.6	7.3	7.3	29.8	7.5
19	7.6	8.0	8.0	7.9	31.5	7.9
20	9.8	9.6	9.2	9.3	37.9	9.5
21	8.1	8.0	7.7	7.9	31.7	7.9

Analysis of Variance

<u>Source</u>	<u>df</u>	<u>ss</u>	<u>Ms</u>	<u>F</u>	<u>5%</u>	<u>1%</u>
Total	83	337.98				
Reps	3	2.43	0.81	3.51		
Lines	20	322.00	16.10	70.00 ^{xx}	1.75	2.20
Error	60	13.55	0.23			

L.S.D. 5% point = .34 x 2.00 = 0.68

1% point = .34 x 2.66 = 0.90

Table 53

Chinese Spring lines with substituted Timstein chromosomes

Chromosome tested	Series 1	Number of Spikelets			Total	1953 Average
		Series 2	Series 3	Series 4		
Timstein	13.2	13.0	12.5	12.4	51.1	12.8
Chinese Spring	22.4	22.5	21.8	22.3	89.0	22.3
1	21.4	20.6	21.9	21.6	85.5	21.4
2	20.5	21.3	20.9	20.9	83.6	20.9
3	20.6	21.6	21.9	21.9	86.0	21.5
4	21.3	21.9	21.9	22.0	87.1	21.8
5	19.5	19.4	19.5	19.6	78.0	19.5
6	20.2	20.0	20.3	20.3	80.8	20.2
7	19.8	19.4	19.6	19.6	78.4	19.6
8	20.6	20.2	20.4	20.4	81.6	20.4
9	20.3	20.5	20.7	20.5	82.0	20.5
10	21.7	21.6	21.8	21.6	86.7	21.7
11	22.5	22.8	22.9	23.0	91.2	22.8
12	20.4	20.6	20.5	20.5	82.0	20.5
15	21.6	21.8	21.9	21.8	87.1	21.8
16	20.8	20.8	20.8	20.8	83.2	20.8
17	22.2	22.1	22.2	22.1	88.6	22.2
18	21.8	21.9	21.9	21.7	87.3	21.8
19	21.3	21.2	21.3	21.3	85.1	21.3
20	20.8	20.8	20.7	20.8	83.1	20.8
21	21.5	21.6	21.6	21.5	86.2	21.6

Source	df	Analysis of Variance			5%	1%
		ss	ms	F		
Total	83	329.87				
Reps	3	0.19	0.063			
Lines	20	325.82	16.29	254.5 ^{xxx}	1.75	2.20
Error	60	3.86	.064			

L.S.D. 5% point = .18 x 2.00 = 0.36

1% point = .18 x 2.66 = 0.48

Summary of the results of the investigation of the effect of the concentration of the solution on the rate of the reaction

Conc. of the solution	Time, min.	Conc. of the solution	Time, min.	Conc. of the solution	Time, min.	Conc. of the solution	Time, min.
0.01	1.00	0.02	1.00	0.03	1.00	0.04	1.00
0.01	2.00	0.02	2.00	0.03	2.00	0.04	2.00
0.01	3.00	0.02	3.00	0.03	3.00	0.04	3.00
0.01	4.00	0.02	4.00	0.03	4.00	0.04	4.00
0.01	5.00	0.02	5.00	0.03	5.00	0.04	5.00
0.01	6.00	0.02	6.00	0.03	6.00	0.04	6.00
0.01	7.00	0.02	7.00	0.03	7.00	0.04	7.00
0.01	8.00	0.02	8.00	0.03	8.00	0.04	8.00
0.01	9.00	0.02	9.00	0.03	9.00	0.04	9.00
0.01	10.00	0.02	10.00	0.03	10.00	0.04	10.00
0.01	11.00	0.02	11.00	0.03	11.00	0.04	11.00
0.01	12.00	0.02	12.00	0.03	12.00	0.04	12.00
0.01	13.00	0.02	13.00	0.03	13.00	0.04	13.00
0.01	14.00	0.02	14.00	0.03	14.00	0.04	14.00
0.01	15.00	0.02	15.00	0.03	15.00	0.04	15.00
0.01	16.00	0.02	16.00	0.03	16.00	0.04	16.00
0.01	17.00	0.02	17.00	0.03	17.00	0.04	17.00
0.01	18.00	0.02	18.00	0.03	18.00	0.04	18.00
0.01	19.00	0.02	19.00	0.03	19.00	0.04	19.00
0.01	20.00	0.02	20.00	0.03	20.00	0.04	20.00
0.01	21.00	0.02	21.00	0.03	21.00	0.04	21.00
0.01	22.00	0.02	22.00	0.03	22.00	0.04	22.00
0.01	23.00	0.02	23.00	0.03	23.00	0.04	23.00
0.01	24.00	0.02	24.00	0.03	24.00	0.04	24.00
0.01	25.00	0.02	25.00	0.03	25.00	0.04	25.00
0.01	26.00	0.02	26.00	0.03	26.00	0.04	26.00
0.01	27.00	0.02	27.00	0.03	27.00	0.04	27.00
0.01	28.00	0.02	28.00	0.03	28.00	0.04	28.00
0.01	29.00	0.02	29.00	0.03	29.00	0.04	29.00
0.01	30.00	0.02	30.00	0.03	30.00	0.04	30.00

Summary of the results of the investigation of the effect of the concentration of the solution on the rate of the reaction

Conc. of the solution	Time, min.	Conc. of the solution	Time, min.	Conc. of the solution	Time, min.	Conc. of the solution	Time, min.
0.01	1.00	0.02	1.00	0.03	1.00	0.04	1.00
0.01	2.00	0.02	2.00	0.03	2.00	0.04	2.00
0.01	3.00	0.02	3.00	0.03	3.00	0.04	3.00
0.01	4.00	0.02	4.00	0.03	4.00	0.04	4.00
0.01	5.00	0.02	5.00	0.03	5.00	0.04	5.00
0.01	6.00	0.02	6.00	0.03	6.00	0.04	6.00
0.01	7.00	0.02	7.00	0.03	7.00	0.04	7.00
0.01	8.00	0.02	8.00	0.03	8.00	0.04	8.00
0.01	9.00	0.02	9.00	0.03	9.00	0.04	9.00
0.01	10.00	0.02	10.00	0.03	10.00	0.04	10.00
0.01	11.00	0.02	11.00	0.03	11.00	0.04	11.00
0.01	12.00	0.02	12.00	0.03	12.00	0.04	12.00
0.01	13.00	0.02	13.00	0.03	13.00	0.04	13.00
0.01	14.00	0.02	14.00	0.03	14.00	0.04	14.00
0.01	15.00	0.02	15.00	0.03	15.00	0.04	15.00
0.01	16.00	0.02	16.00	0.03	16.00	0.04	16.00
0.01	17.00	0.02	17.00	0.03	17.00	0.04	17.00
0.01	18.00	0.02	18.00	0.03	18.00	0.04	18.00
0.01	19.00	0.02	19.00	0.03	19.00	0.04	19.00
0.01	20.00	0.02	20.00	0.03	20.00	0.04	20.00
0.01	21.00	0.02	21.00	0.03	21.00	0.04	21.00
0.01	22.00	0.02	22.00	0.03	22.00	0.04	22.00
0.01	23.00	0.02	23.00	0.03	23.00	0.04	23.00
0.01	24.00	0.02	24.00	0.03	24.00	0.04	24.00
0.01	25.00	0.02	25.00	0.03	25.00	0.04	25.00
0.01	26.00	0.02	26.00	0.03	26.00	0.04	26.00
0.01	27.00	0.02	27.00	0.03	27.00	0.04	27.00
0.01	28.00	0.02	28.00	0.03	28.00	0.04	28.00
0.01	29.00	0.02	29.00	0.03	29.00	0.04	29.00
0.01	30.00	0.02	30.00	0.03	30.00	0.04	30.00

Summary of the results of the investigation of the effect of the concentration of the solution on the rate of the reaction

Summary of the results of the investigation of the effect of the concentration of the solution on the rate of the reaction

Table 54

Chinese Spring lines with substituted Timstein chromosomes

Chromosome tested	Series 1	Spike Density			Total	1953 Average
		Series 2	Series 3	Series 4		
Timstein	1.86	1.73	1.74	1.72	7.05	1.76
Chinese Spring	2.99	2.92	2.79	2.93	11.63	2.91
1	2.81	2.71	2.96	2.81	11.29	2.82
2	2.93	3.07	2.90	2.94	11.84	2.96
3	2.45	2.51	2.64	2.58	10.18	2.54
4	2.92	2.92	2.96	3.06	11.86	2.97
5	2.64	2.62	2.71	2.68	10.65	2.66
6	2.66	2.56	2.71	2.64	10.57	2.64
7	2.79	2.62	2.68	2.65	10.74	2.69
8	2.68	2.56	2.65	2.62	10.51	2.63
9	2.90	2.77	2.80	2.89	11.36	2.84
10	2.68	2.70	2.79	2.77	10.94	2.74
11	2.68	2.59	2.66	2.67	10.60	2.65
12	3.09	3.27	3.20	3.15	12.71	3.18
15	3.00	2.99	3.17	3.11	12.27	3.07
16	2.70	2.63	2.74	2.70	10.77	2.69
17	2.81	2.80	2.67	2.73	11.01	2.75
18	2.86	2.88	3.00	2.97	11.71	2.93
19	2.80	2.65	2.66	2.70	10.81	2.70
20	2.12	2.17	2.25	2.24	8.78	2.19
21	2.65	2.70	2.81	2.72	10.88	2.72

Analysis of Variance

Source	df	ss	ms	F	5%	1%
Total	83	7.50				
Reps	3	0.4	0.133	31.9 ^{xx}	2.76	4.13
Lines	20	7.21	0.361	86.0 ^{xx}	1.75	2.20
Error	60	0.25	0.0042			

$$\text{L.S.D. } t_{.05} = 2.000 \times 0.046 = 0.092$$

$$t_{.01} = 2.660 \times 0.046 = 0.1223$$

TABLE 1. - *Estimated values of the various components of the*

Year	1947	1948	1949	1950	1951	1952
1947	10.5	10.5	10.5	10.5	10.5	10.5
1948	10.5	10.5	10.5	10.5	10.5	10.5
1949	10.5	10.5	10.5	10.5	10.5	10.5
1950	10.5	10.5	10.5	10.5	10.5	10.5
1951	10.5	10.5	10.5	10.5	10.5	10.5
1952	10.5	10.5	10.5	10.5	10.5	10.5
1953	10.5	10.5	10.5	10.5	10.5	10.5
1954	10.5	10.5	10.5	10.5	10.5	10.5
1955	10.5	10.5	10.5	10.5	10.5	10.5
1956	10.5	10.5	10.5	10.5	10.5	10.5
1957	10.5	10.5	10.5	10.5	10.5	10.5
1958	10.5	10.5	10.5	10.5	10.5	10.5
1959	10.5	10.5	10.5	10.5	10.5	10.5
1960	10.5	10.5	10.5	10.5	10.5	10.5
1961	10.5	10.5	10.5	10.5	10.5	10.5
1962	10.5	10.5	10.5	10.5	10.5	10.5
1963	10.5	10.5	10.5	10.5	10.5	10.5
1964	10.5	10.5	10.5	10.5	10.5	10.5
1965	10.5	10.5	10.5	10.5	10.5	10.5
1966	10.5	10.5	10.5	10.5	10.5	10.5
1967	10.5	10.5	10.5	10.5	10.5	10.5
1968	10.5	10.5	10.5	10.5	10.5	10.5
1969	10.5	10.5	10.5	10.5	10.5	10.5
1970	10.5	10.5	10.5	10.5	10.5	10.5
1971	10.5	10.5	10.5	10.5	10.5	10.5
1972	10.5	10.5	10.5	10.5	10.5	10.5
1973	10.5	10.5	10.5	10.5	10.5	10.5
1974	10.5	10.5	10.5	10.5	10.5	10.5
1975	10.5	10.5	10.5	10.5	10.5	10.5
1976	10.5	10.5	10.5	10.5	10.5	10.5
1977	10.5	10.5	10.5	10.5	10.5	10.5
1978	10.5	10.5	10.5	10.5	10.5	10.5
1979	10.5	10.5	10.5	10.5	10.5	10.5
1980	10.5	10.5	10.5	10.5	10.5	10.5

TABLE 2. - *Estimated values of the various components of the*

Year	1947	1948	1949	1950	1951	1952
1947	10.5	10.5	10.5	10.5	10.5	10.5
1948	10.5	10.5	10.5	10.5	10.5	10.5
1949	10.5	10.5	10.5	10.5	10.5	10.5
1950	10.5	10.5	10.5	10.5	10.5	10.5
1951	10.5	10.5	10.5	10.5	10.5	10.5
1952	10.5	10.5	10.5	10.5	10.5	10.5

$$10.5 = 10.5 + 10.5 + 10.5 + 10.5 + 10.5 + 10.5$$

$$10.5 = 10.5 + 10.5 + 10.5 + 10.5 + 10.5 + 10.5$$

Table 55

Chinese Spring lines with substituted Timstein chromosomes

Chromosome tested	Series 1	Spike Length			Total	1954 Average
		Series 2	Series 3	Series 4		
Timstein	5.6	6.0	6.0	6.0	23.6	5.90
Chinese Spring	6.4	6.1	6.4	6.6	25.5	6.38
1	6.8	6.5	6.3	6.5	26.1	6.53
2	5.6	5.4	5.8	6.3	23.1	5.78
3	7.1	6.8	7.0	6.8	27.7	6.93
4	5.6	5.7	5.7	6.2	23.2	5.80
5	6.3	5.9	6.2	6.4	24.8	6.20
6	6.0	5.9	6.5	6.3	24.7	6.18
7	5.7	5.8	5.9	6.0	23.4	5.85
8	6.2	6.4	6.4	6.0	25.0	6.25
9	5.3	5.5	5.6	5.6	22.0	5.50
10	6.8	6.7	6.7	7.0	27.2	6.80
11	7.0	7.0	7.4	7.3	28.7	7.18
12	5.4	5.0	5.6	5.6	21.6	5.40
15	6.5	6.5	6.3	6.7	26.0	6.50
16	6.5	6.5	6.6	6.6	26.2	6.55
17	6.3	6.4	6.2	6.6	25.5	6.38
18	6.2	6.0	6.3	6.1	24.6	6.15
19	6.7	6.6	6.8	7.1	27.2	6.80
20	7.8	7.6	8.0	7.9	31.3	7.83
21	6.8	6.5	6.6	6.7	26.6	6.65

Analysis of Variance

Source	df	ss	ms	F	5%	1%
Total	83	28.88				
Reps	3	0.79	0.263	8.22		
Lines	20	26.26	1.313	41.03 ^{xxx}	1.75	2.20
Error	60	1.94	0.032			

L.S.D. 5% point = .126 x 2.00 = .252

1% point = .126 x 2.66 = .435

Table 1. Summary of the data for the first 1000 iterations of the simulation.

Iteration	Time (s)	Distance (km)	Speed (km/h)	Acceleration (m/s ²)	Angle (deg)	Altitude (m)
0.0	0.00	0.0	0.0	0.0	0.0	0.0
0.1	0.01	0.1	1.0	1.0	0.1	0.1
0.2	0.02	0.2	2.0	2.0	0.2	0.2
0.3	0.03	0.3	3.0	3.0	0.3	0.3
0.4	0.04	0.4	4.0	4.0	0.4	0.4
0.5	0.05	0.5	5.0	5.0	0.5	0.5
0.6	0.06	0.6	6.0	6.0	0.6	0.6
0.7	0.07	0.7	7.0	7.0	0.7	0.7
0.8	0.08	0.8	8.0	8.0	0.8	0.8
0.9	0.09	0.9	9.0	9.0	0.9	0.9
1.0	0.10	1.0	10.0	10.0	1.0	1.0
1.1	0.11	1.1	11.0	11.0	1.1	1.1
1.2	0.12	1.2	12.0	12.0	1.2	1.2
1.3	0.13	1.3	13.0	13.0	1.3	1.3
1.4	0.14	1.4	14.0	14.0	1.4	1.4
1.5	0.15	1.5	15.0	15.0	1.5	1.5
1.6	0.16	1.6	16.0	16.0	1.6	1.6
1.7	0.17	1.7	17.0	17.0	1.7	1.7
1.8	0.18	1.8	18.0	18.0	1.8	1.8
1.9	0.19	1.9	19.0	19.0	1.9	1.9
2.0	0.20	2.0	20.0	20.0	2.0	2.0
2.1	0.21	2.1	21.0	21.0	2.1	2.1
2.2	0.22	2.2	22.0	22.0	2.2	2.2
2.3	0.23	2.3	23.0	23.0	2.3	2.3
2.4	0.24	2.4	24.0	24.0	2.4	2.4
2.5	0.25	2.5	25.0	25.0	2.5	2.5
2.6	0.26	2.6	26.0	26.0	2.6	2.6
2.7	0.27	2.7	27.0	27.0	2.7	2.7
2.8	0.28	2.8	28.0	28.0	2.8	2.8
2.9	0.29	2.9	29.0	29.0	2.9	2.9
3.0	0.30	3.0	30.0	30.0	3.0	3.0
3.1	0.31	3.1	31.0	31.0	3.1	3.1
3.2	0.32	3.2	32.0	32.0	3.2	3.2
3.3	0.33	3.3	33.0	33.0	3.3	3.3
3.4	0.34	3.4	34.0	34.0	3.4	3.4
3.5	0.35	3.5	35.0	35.0	3.5	3.5
3.6	0.36	3.6	36.0	36.0	3.6	3.6
3.7	0.37	3.7	37.0	37.0	3.7	3.7
3.8	0.38	3.8	38.0	38.0	3.8	3.8
3.9	0.39	3.9	39.0	39.0	3.9	3.9
4.0	0.40	4.0	40.0	40.0	4.0	4.0
4.1	0.41	4.1	41.0	41.0	4.1	4.1
4.2	0.42	4.2	42.0	42.0	4.2	4.2
4.3	0.43	4.3	43.0	43.0	4.3	4.3
4.4	0.44	4.4	44.0	44.0	4.4	4.4
4.5	0.45	4.5	45.0	45.0	4.5	4.5
4.6	0.46	4.6	46.0	46.0	4.6	4.6
4.7	0.47	4.7	47.0	47.0	4.7	4.7
4.8	0.48	4.8	48.0	48.0	4.8	4.8
4.9	0.49	4.9	49.0	49.0	4.9	4.9
5.0	0.50	5.0	50.0	50.0	5.0	5.0

Table 2. Summary of the data for the last 1000 iterations of the simulation.

Iteration	Time (s)	Distance (km)	Speed (km/h)	Acceleration (m/s ²)	Angle (deg)	Altitude (m)
900.0	45.00	45.0	45.0	45.0	45.0	45.0
900.1	45.01	45.1	45.1	45.1	45.1	45.1
900.2	45.02	45.2	45.2	45.2	45.2	45.2
900.3	45.03	45.3	45.3	45.3	45.3	45.3
900.4	45.04	45.4	45.4	45.4	45.4	45.4
900.5	45.05	45.5	45.5	45.5	45.5	45.5
900.6	45.06	45.6	45.6	45.6	45.6	45.6
900.7	45.07	45.7	45.7	45.7	45.7	45.7
900.8	45.08	45.8	45.8	45.8	45.8	45.8
900.9	45.09	45.9	45.9	45.9	45.9	45.9

$$d(t) = \frac{1}{2} a t^2 + v_0 t + d_0$$

$$v(t) = a t + v_0$$

Table 56

Chinese Spring lines with substituted Timstein chromosomes

Chromosome tested	Series 1	Number of Spikelets			Total	1954 Average
		Series 2	Series 3	Series 4		
Timstein	11.9	12.5	11.9	12.0	48.3	12.08
Chinese Spring	22.1	21.5	22.0	22.0	87.6	21.90
1	21.8	21.9	20.7	21.8	86.2	21.55
2	20.3	19.7	22.5	21.1	83.6	20.90
3	21.3	20.9	22.1	19.8	84.1	21.03
4	20.0	21.1	20.7	22.3	84.1	21.03
5	19.4	19.9	19.6	19.8	78.7	19.68
6	19.1	19.1	20.8	20.6	79.6	19.90
7	19.3	19.5	19.3	19.5	77.6	19.40
8	19.3	20.5	20.7	20.1	80.6	20.15
9	19.8	20.3	20.1	20.1	80.3	20.08
10	20.7	20.7	21.3	21.3	84.0	21.00
11	22.1	21.4	21.9	22.2	87.6	21.90
12	20.3	19.3	20.5	19.3	79.4	19.85
15	22.2	22.3	21.7	21.3	87.5	21.88
16	21.3	21.1	21.3	21.7	85.4	21.35
17	21.8	21.3	21.5	21.9	86.5	21.63
18	21.5	21.6	22.5	20.8	86.4	21.60
19	21.1	20.6	21.6	22.3	85.6	21.40
20	21.1	21.2	21.9	21.1	85.3	21.33
21	21.8	20.8	21.3	22.2	86.3	21.53

Analysis of Variance

<u>Source</u>	<u>df</u>	<u>ss</u>	<u>ms</u>	<u>F</u>	<u>5%</u>	<u>1%</u>
Total	83	373.26				
Reps	3	2.44	0.813	2.377		
Lines	20	350.21	17.511	51.202 ^{xx}	1.75	2.20
Error	60	20.51	0.342			

L.S.D. 5% point = $2.00 \times 0.414 = 0.828$ 1% point = $2.66 \times 0.414 = 1.101$

Table 2. The results of the analysis of variance for the different factors.

Factor	Sum of squares	df	Mean square	F	P	Significance
1. Age	10.21	2	5.105	1.34	0.27	ns
2. Sex	0.12	1	0.12	0.03	0.86	ns
3. Education	0.12	2	0.06	0.02	0.98	ns
4. Occupation	0.12	2	0.06	0.02	0.98	ns
5. Income	0.12	2	0.06	0.02	0.98	ns
6. Religion	0.12	2	0.06	0.02	0.98	ns
7. Marital status	0.12	2	0.06	0.02	0.98	ns
8. Ethnicity	0.12	2	0.06	0.02	0.98	ns
9. Nationality	0.12	2	0.06	0.02	0.98	ns
10. Residence	0.12	2	0.06	0.02	0.98	ns
11. Duration of stay	0.12	2	0.06	0.02	0.98	ns
12. Length of stay	0.12	2	0.06	0.02	0.98	ns
13. Type of stay	0.12	2	0.06	0.02	0.98	ns
14. Reason for stay	0.12	2	0.06	0.02	0.98	ns
15. Accommodation	0.12	2	0.06	0.02	0.98	ns
16. Food	0.12	2	0.06	0.02	0.98	ns
17. Health	0.12	2	0.06	0.02	0.98	ns
18. Safety	0.12	2	0.06	0.02	0.98	ns
19. Security	0.12	2	0.06	0.02	0.98	ns
20. Comfort	0.12	2	0.06	0.02	0.98	ns
21. Convenience	0.12	2	0.06	0.02	0.98	ns
22. Accessibility	0.12	2	0.06	0.02	0.98	ns
23. Affordability	0.12	2	0.06	0.02	0.98	ns
24. Availability	0.12	2	0.06	0.02	0.98	ns
25. Reliability	0.12	2	0.06	0.02	0.98	ns
26. Quality	0.12	2	0.06	0.02	0.98	ns
27. Quantity	0.12	2	0.06	0.02	0.98	ns
28. Variety	0.12	2	0.06	0.02	0.98	ns
29. Freshness	0.12	2	0.06	0.02	0.98	ns
30. Taste	0.12	2	0.06	0.02	0.98	ns
31. Texture	0.12	2	0.06	0.02	0.98	ns
32. Appearance	0.12	2	0.06	0.02	0.98	ns
33. Smell	0.12	2	0.06	0.02	0.98	ns
34. Sound	0.12	2	0.06	0.02	0.98	ns
35. Touch	0.12	2	0.06	0.02	0.98	ns
36. Weight	0.12	2	0.06	0.02	0.98	ns
37. Volume	0.12	2	0.06	0.02	0.98	ns
38. Density	0.12	2	0.06	0.02	0.98	ns
39. Hardness	0.12	2	0.06	0.02	0.98	ns
40. Softness	0.12	2	0.06	0.02	0.98	ns
41. Elasticity	0.12	2	0.06	0.02	0.98	ns
42. Brittleness	0.12	2	0.06	0.02	0.98	ns
43. Malleability	0.12	2	0.06	0.02	0.98	ns
44. Ductility	0.12	2	0.06	0.02	0.98	ns
45. Weldability	0.12	2	0.06	0.02	0.98	ns
46. Castability	0.12	2	0.06	0.02	0.98	ns
47. Machinability	0.12	2	0.06	0.02	0.98	ns
48. Formability	0.12	2	0.06	0.02	0.98	ns
49. Drawability	0.12	2	0.06	0.02	0.98	ns
50. Flattenable	0.12	2	0.06	0.02	0.98	ns
51. Stretchability	0.12	2	0.06	0.02	0.98	ns
52. Compressibility	0.12	2	0.06	0.02	0.98	ns
53. Expandability	0.12	2	0.06	0.02	0.98	ns
54. Contractibility	0.12	2	0.06	0.02	0.98	ns
55. Shrinkability	0.12	2	0.06	0.02	0.98	ns
56. Swellability	0.12	2	0.06	0.02	0.98	ns
57. Absorbability	0.12	2	0.06	0.02	0.98	ns
58. Permeability	0.12	2	0.06	0.02	0.98	ns
59. Impermability	0.12	2	0.06	0.02	0.98	ns
60. Sealing	0.12	2	0.06	0.02	0.98	ns
61. Adhesiveness	0.12	2	0.06	0.02	0.98	ns
62. Cohesiveness	0.12	2	0.06	0.02	0.98	ns
63. Adhesivity	0.12	2	0.06	0.02	0.98	ns
64. Cohesivity	0.12	2	0.06	0.02	0.98	ns
65. Stickiness	0.12	2	0.06	0.02	0.98	ns
66. Greasiness	0.12	2	0.06	0.02	0.98	ns
67. Slipperiness	0.12	2	0.06	0.02	0.98	ns
68. Tackiness	0.12	2	0.06	0.02	0.98	ns
69. Glossiness	0.12	2	0.06	0.02	0.98	ns
70. Dullness	0.12	2	0.06	0.02	0.98	ns
71. Transparency	0.12	2	0.06	0.02	0.98	ns
72. Opacity	0.12	2	0.06	0.02	0.98	ns
73. Reflectivity	0.12	2	0.06	0.02	0.98	ns
74. Absorptivity	0.12	2	0.06	0.02	0.98	ns
75. Emissivity	0.12	2	0.06	0.02	0.98	ns
76. Conductivity	0.12	2	0.06	0.02	0.98	ns
77. Resistivity	0.12	2	0.06	0.02	0.98	ns
78. Permittivity	0.12	2	0.06	0.02	0.98	ns
79. Penetrability	0.12	2	0.06	0.02	0.98	ns
80. Impenetrability	0.12	2	0.06	0.02	0.98	ns
81. Solubility	0.12	2	0.06	0.02	0.98	ns
82. Insolubility	0.12	2	0.06	0.02	0.98	ns
83. Volatility	0.12	2	0.06	0.02	0.98	ns
84. Nonvolatility	0.12	2	0.06	0.02	0.98	ns
85. Flammability	0.12	2	0.06	0.02	0.98	ns
86. Nonflammability	0.12	2	0.06	0.02	0.98	ns
87. Ignitability	0.12	2	0.06	0.02	0.98	ns
88. Nonignitability	0.12	2	0.06	0.02	0.98	ns
89. Combustibility	0.12	2	0.06	0.02	0.98	ns
90. Noncombustibility	0.12	2	0.06	0.02	0.98	ns
91. Explosibility	0.12	2	0.06	0.02	0.98	ns
92. Nonexplosibility	0.12	2	0.06	0.02	0.98	ns
93. Corrosibility	0.12	2	0.06	0.02	0.98	ns
94. Noncorrosibility	0.12	2	0.06	0.02	0.98	ns
95. Oxidizability	0.12	2	0.06	0.02	0.98	ns
96. Nonoxidizability	0.12	2	0.06	0.02	0.98	ns
97. Reducibility	0.12	2	0.06	0.02	0.98	ns
98. Nonreducibility	0.12	2	0.06	0.02	0.98	ns
99. Reactivity	0.12	2	0.06	0.02	0.98	ns
100. Nonreactivity	0.12	2	0.06	0.02	0.98	ns

ns = not significant

Factor	Sum of squares	df	Mean square	F	P	Significance
1. Age	10.21	2	5.105	1.34	0.27	ns
2. Sex	0.12	1	0.12	0.03	0.86	ns
3. Education	0.12	2	0.06	0.02	0.98	ns
4. Occupation	0.12	2	0.06	0.02	0.98	ns
5. Income	0.12	2	0.06	0.02	0.98	ns
6. Religion	0.12	2	0.06	0.02	0.98	ns
7. Marital status	0.12	2	0.06	0.02	0.98	ns
8. Ethnicity	0.12	2	0.06	0.02	0.98	ns
9. Nationality	0.12	2	0.06	0.02	0.98	ns
10. Residence	0.12	2	0.06	0.02	0.98	ns
11. Duration of stay	0.12	2	0.06	0.02	0.98	ns
12. Length of stay	0.12	2	0.06	0.02	0.98	ns
13. Type of stay	0.12	2	0.06	0.02	0.98	ns
14. Reason for stay	0.12	2	0.06	0.02	0.98	ns
15. Accommodation	0.12	2	0.06	0.02	0.98	ns
16. Food	0.12	2	0.06	0.02	0.98	ns
17. Health	0.12	2	0.06	0.02	0.98	ns
18. Safety	0.12	2	0.06	0.02	0.98	ns
19. Security	0.12	2	0.06	0.02	0.98	ns
20. Comfort	0.12	2	0.06	0.02	0.98	ns
21. Convenience	0.12	2	0.06	0.02	0.98	ns
22. Accessibility	0.12	2	0.06	0.02	0.98	ns
23. Affordability	0.12	2	0.06	0.02	0.98	ns
24. Availability	0.12	2	0.06	0.02	0.98	ns
25. Reliability	0.12	2	0.06	0.02	0.98	ns
26. Quality	0.12	2	0.06	0.02	0.98	ns
27. Quantity	0.12	2	0.06	0.02	0.98	ns
28. Variety	0.12	2	0.06	0.02	0.98	ns
29. Freshness	0.12	2	0.06	0.02	0.98	ns
30. Taste	0.12	2	0.06	0.02	0.98	ns
31. Texture	0.12	2	0.06	0.02	0.98	ns
32. Appearance	0.12	2	0.06	0.02	0.98	ns
33. Smell	0.12	2	0.06	0.02	0.98	ns
34. Sound	0.12	2	0.06	0.02	0.98	ns
35. Touch	0.12	2	0.06	0.02	0.98	ns
36. Weight	0.12	2	0.06	0.02	0.98	ns
37. Volume	0.12	2	0.06	0.02	0.98	ns
38. Density	0.12	2	0.06	0.02	0.98	ns
39. Hardness	0.12	2	0.06	0.02	0.98	ns
40. Softness	0.12	2	0.06	0.02	0.98	ns
41. Elasticity	0.12	2	0.06	0.02	0.98	ns
42. Brittleness	0.12	2	0.06	0.02	0.98	ns
43. Malleability	0.12	2	0.06	0.02	0.98	ns
44. Ductility	0.12	2	0.06	0.02	0.98	ns
45. Weldability	0.12	2	0.06	0.02	0.98	ns
46. Castability	0.12	2	0.06	0.02	0.98	ns
47. Machinability	0.12	2	0.06	0.02	0.98	ns
48. Formability	0.12	2	0.06	0.02	0.98	ns
49. Drawability	0.12	2	0.06	0.02	0.98	ns
50. Flattenable	0.12	2	0.06	0.02	0.98	ns
51. Stretchability	0.12	2	0.06	0.02	0.98	ns
52. Compressibility	0.12	2	0.06	0.02	0.98	ns
53. Expandability	0.12	2	0.06	0.02	0.98	ns
54. Contractibility	0.12	2	0.06	0.02	0.98	ns
55. Shrinkability	0.12	2	0.06	0.02	0.98	ns
56. Swellability	0.12	2	0.06	0.02	0.98	ns
57. Absorbability	0.12	2	0.06	0.02	0.98	ns
58. Permeability	0.12	2	0.06	0.02	0.98	ns
59. Impermability	0.12	2	0.06	0.02	0.98	ns
60. Sealing	0.12	2	0.06	0.02	0.98	ns
61. Adhesiveness	0.12	2	0.06	0.02	0.98	ns
62. Cohesiveness	0.12	2	0.06	0.02	0.98	ns
63. Adhesivity	0.12	2	0.06	0.02	0.98	ns
64. Cohesivity	0.12	2	0.06	0.02	0.98	ns
65. Stickiness	0.12	2	0.06	0.02	0.98	ns
66. Greasiness	0.12	2	0.06	0.02	0.98	ns
67. Slipperiness	0.12	2	0.06	0.02	0.98	ns
68. Tackiness	0.12	2	0.06	0.02	0.98	ns
69. Glossiness	0.12	2	0.06	0.02	0.98	ns
70. Dullness	0.12	2	0.06	0.02	0.98	ns
71. Transparency	0.12	2	0.06	0.02	0.98	ns
72. Opacity	0.12	2	0.06	0.02	0.98	ns
73. Reflectivity	0.12	2	0.06	0.02	0.98	ns
74. Absorptivity	0.12	2	0.06	0.02	0.98	ns
75. Emissivity	0.12	2	0.06	0.02	0.98	ns
76. Conductivity	0.12	2	0.06	0.02	0.98	ns
77. Resistivity	0.12	2	0.06	0.02	0.98	ns
78. Permittivity	0.12	2	0.06	0.02	0.98	ns
79. Penetrability	0.12	2	0.06	0.02	0.98	ns
80. Impenetrability	0.12	2	0.06	0.02	0.98	ns
81. Solubility	0.12	2	0.06	0.02	0.98	ns
82. Insolubility	0.12	2	0.06	0.02	0.98	ns
83. Volatility	0.12	2	0.06	0.02	0.98	ns
84. Nonvolatility	0.12	2	0.06	0.02	0.98	ns
85. Flammability	0.12	2	0.06	0.02	0.98	ns
86. Nonflammability	0.12	2	0.06	0.02	0.98	ns
87. Ignitability	0.12	2	0.06	0.02	0.98	ns
88. Nonignitability	0.12	2	0.06	0.02	0.98	ns
89. Combustibility	0.12	2	0.06	0.02	0.98	ns
90. Noncombustibility	0.12	2	0.06	0.02	0.98	ns

Table 57

Chinese Spring lines with substituted Timstein chromosomes

Chromosome tested	Spike Density				Total	1954 Average
	Series 1	Series 2	Series 3	Series 4		
Timstein	2.13	2.08	1.98	2.00	8.19	2.05
Chinese Spring	3.45	3.52	3.44	3.33	13.74	3.44
1	3.20	3.37	3.29	3.35	13.21	3.30
2	3.63	3.65	3.88	3.35	14.51	3.63
3	3.00	3.07	3.16	2.91	12.14	3.04
4	3.57	3.70	3.63	3.60	14.50	3.63
5	3.08	3.37	3.16	3.09	12.70	3.18
6	3.18	3.24	3.20	3.27	12.89	3.22
7	3.39	3.36	3.27	3.10	13.12	3.28
8	3.11	3.20	3.23	3.35	12.89	3.22
9	3.74	3.69	3.59	3.59	14.61	3.65
10	3.04	3.09	3.18	3.04	12.35	3.09
11	3.16	3.06	2.96	3.04	12.22	3.06
12	3.76	3.86	3.66	3.45	14.73	3.68
15	3.42	3.43	3.44	3.18	13.47	3.37
16	3.28	3.25	3.38	3.29	13.20	3.30
17	3.46	3.33	3.46	3.32	13.57	3.39
18	3.47	3.60	3.57	3.41	14.05	3.51
19	3.15	3.12	3.18	3.14	12.59	3.15
20	2.71	2.79	2.74	2.80	11.04	2.76
21	3.21	3.20	3.22	3.31	12.94	3.24

Analysis of Variance

Source	df	ss	ms	F	5%	1%
Total	83	10.99				
Reps	3	0.12	0.040	4.7 ^{xx}	2.76	4.13
Lines	20	10.36	0.518	60.94 ^{xx}	1.75	2.20
Error	60	0.51	0.0085			

L.S.D. 5% point = $2.00 \times 0.0652 = 0.1304$ 1% point = $2.66 \times 0.0652 = 0.1734$

Table 1. Summary of the data for the 100 cases.

Case	Age	Sex	Height	Weight	BP	Heart rate
1	25	M	170	65	120/80	72
2	26	F	165	60	115/75	68
3	27	M	175	70	125/85	75
4	28	F	160	55	110/70	65
5	29	M	172	68	122/82	73
6	30	F	168	62	118/78	70
7	31	M	178	75	130/90	78
8	32	F	162	58	112/72	66
9	33	M	174	72	128/88	76
10	34	F	164	60	116/76	69
11	35	M	176	74	132/92	80
12	36	F	166	62	120/80	72
13	37	M	179	78	135/95	82
14	38	F	168	64	122/82	74
15	39	M	180	80	140/100	85
16	40	F	170	68	125/85	76
17	41	M	182	85	145/105	90
18	42	F	172	70	130/90	80
19	43	M	184	90	150/110	95
20	44	F	174	75	135/95	85
21	45	M	186	95	155/115	100
22	46	F	176	78	140/100	90
23	47	M	188	100	160/120	105
24	48	F	178	80	145/105	95
25	49	M	190	105	165/125	110
26	50	F	180	85	150/110	100
27	51	M	192	110	170/130	115
28	52	F	182	88	155/115	105
29	53	M	194	115	175/135	120
30	54	F	184	90	160/120	110
31	55	M	196	120	180/140	125
32	56	F	186	95	165/125	115
33	57	M	198	125	185/145	130
34	58	F	188	100	170/130	120
35	59	M	200	130	190/150	135
36	60	F	190	105	175/135	125
37	61	M	202	135	195/155	140
38	62	F	192	110	180/140	130
39	63	M	204	140	200/160	145
40	64	F	194	115	185/145	135
41	65	M	206	145	205/165	150
42	66	F	196	120	190/150	140
43	67	M	208	150	210/170	155
44	68	F	198	125	195/155	145
45	69	M	210	155	215/175	160
46	70	F	200	130	200/160	150
47	71	M	212	160	220/180	165
48	72	F	202	135	205/165	155
49	73	M	214	165	225/185	170
50	74	F	204	140	210/170	160
51	75	M	216	170	230/190	175
52	76	F	206	145	215/175	165
53	77	M	218	175	235/195	180
54	78	F	208	150	220/180	170
55	79	M	220	180	240/200	185
56	80	F	210	155	225/185	175
57	81	M	222	185	245/205	190
58	82	F	212	160	230/190	180
59	83	M	224	190	250/210	195
60	84	F	214	165	235/195	185
61	85	M	226	195	255/215	200
62	86	F	216	170	240/200	190
63	87	M	228	200	260/220	205
64	88	F	218	175	245/205	195
65	89	M	230	205	265/225	210
66	90	F	220	180	250/210	200
67	91	M	232	210	270/230	215
68	92	F	222	185	255/215	205
69	93	M	234	215	275/235	220
70	94	F	224	190	260/220	210
71	95	M	236	220	280/240	225
72	96	F	226	195	265/225	215
73	97	M	238	225	285/245	230
74	98	F	228	200	270/230	220
75	99	M	240	230	290/250	235
76	100	F	230	205	275/235	225

Table 2. Summary of the data for the 100 cases.

Case	Age	Sex	Height	Weight	BP	Heart rate
1	25	M	170	65	120/80	72
2	26	F	165	60	115/75	68
3	27	M	175	70	125/85	75
4	28	F	160	55	110/70	65
5	29	M	172	68	122/82	73
6	30	F	168	62	118/78	70
7	31	M	178	75	130/90	78
8	32	F	162	58	112/72	66
9	33	M	174	72	128/88	76
10	34	F	164	60	116/76	69
11	35	M	176	74	132/92	80
12	36	F	166	62	120/80	72
13	37	M	179	78	135/95	82
14	38	F	168	64	122/82	74
15	39	M	180	80	140/100	85
16	40	F	170	68	125/85	76
17	41	M	182	85	145/105	90
18	42	F	172	70	130/90	80
19	43	M	184	90	150/110	95
20	44	F	174	75	135/95	85
21	45	M	186	95	155/115	100
22	46	F	176	78	140/100	90
23	47	M	188	100	160/120	105
24	48	F	178	80	145/105	95
25	49	M	190	105	165/125	110
26	50	F	180	85	150/110	100
27	51	M	192	110	170/130	115
28	52	F	182	88	155/115	105
29	53	M	194	115	175/135	120
30	54	F	184	90	160/120	110
31	55	M	196	120	180/140	125
32	56	F	186	95	165/125	115
33	57	M	198	125	185/145	130
34	58	F	188	100	170/130	120
35	59	M	200	130	190/150	135
36	60	F	190	105	175/135	125
37	61	M	202	135	195/155	140
38	62	F	192	110	180/140	130
39	63	M	204	140	200/160	145
40	64	F	194	115	185/145	135
41	65	M	206	145	205/165	150
42	66	F	196	120	190/150	140
43	67	M	208	150	210/170	155
44	68	F	198	125	195/155	145
45	69	M	210	155	215/175	160
46	70	F	200	130	200/160	150
47	71	M	212	160	220/180	165
48	72	F	202	135	205/165	155
49	73	M	214	165	225/185	170
50	74	F	204	140	210/170	160
51	75	M	216	170	230/190	175
52	76	F	206	145	215/175	165
53	77	M	218	175	235/195	180
54	78	F	208	150	220/180	170
55	79	M	220	180	240/200	185
56	80	F	210	155	225/185	175
57	81	M	222	185	245/205	190
58	82	F	212	160	230/190	180
59	83	M	224	190	250/210	195
60	84	F	214	165	235/195	185
61	85	M	226	195	255/215	200
62	86	F	216	170	240/200	190
63	87	M	228	200	260/220	205
64	88	F	218	175	245/205	195
65	89	M	230	205	265/225	210
66	90	F	220	180	250/210	200
67	91	M	232	210	270/230	215
68	92	F	222	185	255/215	205
69	93	M	234	215	275/235	220
70	94	F	224	190	260/220	210
71	95	M	236	220	280/240	225
72	96	F	226	195	265/225	215
73	97	M	238	225	285/245	230
74	98	F	228	200	270/230	220
75	99	M	240	230	290/250	235
76	100	F	230	205	275/235	225

$$100.0 = 100.0 + 0.0 = 100.0$$

$$100.0 = 100.0 + 0.0 = 100.0$$

Table 58

Computation of lines x years interaction from composite of 3 sets of substitution lines in 1953 and 1954

Chromosome tested	Thatcher			1954			1953			Hope			1954			1953			Timstein			1954		
	Rep			Rep			Rep			Rep			Rep			Rep			Rep			Rep		
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Chinese Spring	560	520	550	560	290	360	350	360	590	650	640	530	380	365	390	385	630	575	600	630	350	350	345	310
1	1020	1060	970	1020	500	535	460	730	840	950	830	880	450	485	550	620	980	950	935	875	500	590	560	530
2	810	760	750	790	470	460	410	630	550	650	670	640	330	480	500	510	700	560	670	550	500	540	460	430
3	750	770	800	690	520	370	470	640	600	700	620	660	345	450	340	630	710	610	670	680	450	530	380	420
4	620	550	570	610	285	240	275	290	670	650	680	650	430	515	490	550	820	750	800	740	490	530	425	500
5	900	780	740	750	440	450	525	640	740	700	700	800	425	460	520	510	650	730	620	590	425	470	460	520
6	640	560	570	530	600	400	430	650	800	760	750	680	450	420	495	635	640	630	700	665	335	530	555	450
7	750	720	720	710	420	480	530	520	830	860	780	760	510	460	560	590	640	520	740	580	500	430	500	490
8	800	930	810	900	490	530	500	600	810	740	730	800	400	480	450	710	850	850	810	960	480	610	580	440
9	760	760	810	780	490	410	420	550	750	740	830	680	415	490	530	570	580	545	520	600	530	480	450	325
10	680	680	720	650	460	520	420	430	750	710	750	700	390	530	550	580	435	470	320	490	400	340	540	430
11	560	560	480	490	210	325	265	300	520	520	600	570	320	370	325	410	580	630	650	615	380	450	425	400
12	720	720	740	750	470	570	400	550	900	840	930	840	535	520	540	600	570	650	700	725	460	460	470	420
15	530	500	450	650	435	310	410	465	550	640	650	660	440	485	430	550	640	600	770	460	310	320	360	490
16	580	620	530	540	400	420	330	425	570	490	570	640	330	385	380	410	570	750	730	710	335	480	540	620
19	640	700	660	600	520	425	485	550	430	630	680	760	420	380	435	430	750	830	960	720	535	520	490	565
20	640	580	570	610	375	530	415	460	600	610	600	600	330	420	405	415	615	630	620	660	420	390	450	420
21	700	680	820	710	425	390	550	530	730	780	850	750	430	470	580	565	710	720	660	615	435	310	450	505

Table 58 (continued)

Source of Variance	Analysis of Variance				
	df	ss	ms	F	$\frac{5\%}{1\%}$
Reps	3	86866.0	28955.3		
Years	1	5678752.1	5678752.1		
Varieties	2	27067.8	13533.9		
YxV	2	9005.6	4502.8		
Error (1)	15	220780.5	14718.7		
Lines	17	2003724.8	117866.2		
LxY	17	34033.1	2001.9	0.07	1.93
LxV	34	1037489.7	30514.4	6.05 ^x	1.47
LxYxV	34	59491.7	1749.8	0.35	1.47
Error (2)	306	1543088.5	5042.8		
		<u>LxYxV</u>	<u>LxV</u>	<u>L</u>	
L.S.D.	5% level	98.9	98.9	144.9	
	1% level	130.0	130.0	194.6	

Table 59

Computation of lines x varieties interaction of yield from composite of 3 sets of substitution lines in 1953.

Chromosome tested	Thatcher (1)	Ave.	Hope	Ave.	Timstein	Ave.
Chinese Spring	560	520	550	560	547.5	590
1	1020	1060	970	1020	1017.5	840
2	810	760	750	790	777.5	550
3	750	770	800	690	752.5	600
4	620	550	570	610	587.5	670
5	900	780	740	750	792.5	740
6	640	560	570	530	575.0	800
7	750	720	720	710	725.0	830
8	800	930	810	900	860.0	810
9	760	760	810	780	777.5	750
10	680	680	720	650	682.5	750
11	560	560	480	490	522.5	520
12	720	720	740	750	732.5	900
15	530	500	450	650	532.5	550
16	580	620	530	540	567.5	570
19	640	700	660	600	650.0	430
20	640	580	570	610	600.0	600
21	700	680	820	710	727.5	730

Analysis of Variance

Source	df	ss	ms	F	5%	1%
Total	215					
Reps	3	6524	2175.0			
Varieties	2	26203	13102.0			
Error (1)	6	21247	3541.0			
Lines	17	1777660	104568.0			
Lines x varieties	34	986639	29019	9.07xx	1.51	1.78
Error (2)	153	489554	3200			
L.S.D.	5% level		79.1			
	1% level		104.6			

Table 61

Chinese Spring lines with substituted Thatcher chromosomes

Chromosome tested	Series 1	Yield in Grams			1952	
		Series 2	Series 3	Series 4	Total	Average
Thatcher	955	1020	1040	1000	4015	1003.75
Chinese Spring	661	612	740	655	2668	667.00
1	840	1000	900	895	3635	908.75
2	785	855	708	755	3103	775.75
3	840	800	885	880	3405	851.25
4	724	535	835	545	2639	659.75
5	846	795	763	562	2966	741.50
6	883	870	805	655	3213	803.25
7	631	813	487	762	2693	673.25
8	942	1008	840	845	3635	908.75
9	864	670	860	735	3129	782.25
10	934	620	600	807	2961	740.25
11	686	780	588	644	2698	674.50
12	782	1000	925	1092	3799	949.75
15	791	773	820	842	3226	806.50
16	463	320	634	360	1777	444.25
17	615	708	632	862	2817	704.25
19	812	1055	665	695	3227	806.75
20	712	740	762	740	2954	738.50
21	766	825	836	890	3317	829.25

Analysis of Variance

Source	df	ss	ms	F	5%	1%
Total	79	1819960				
Reps	3	9756	3252	0.292		
Lines	19	1174666	61815	5.54 ^{xx}	1.72	2.15
Error	57	635538	11150			

L.S.D. - 5% point - 149.35

1% point - 198.88

Table 62

Chinese Spring lines with substituted Thatcher chromosomes

Chromosome tested	Series 1	Yield in Grams			1953	
		Series 2	Series 3	Series 4	Total	Average
Thatcher	1200	1210	1250	1160	4820	1205
Chinese Spring	560	520	550	560	2190	547.5
1	1020	1060	970	1020	4070	1017.5
2	810	760	750	790	3110	777.5
3	750	770	800	690	3010	752.5
4	620	550	570	610	2350	587.5
5	900	780	740	750	3170	792.5
6	640	560	570	530	2300	575.0
7	750	720	720	710	2900	725.0
8	800	930	810	900	3440	860.0
9	760	760	810	780	3110	777.5
10	680	680	720	650	2730	682.5
11	560	560	480	490	2090	522.5
12	720	720	740	750	2930	732.5
13	570	590	600	540	2300	575.0
15	530	500	450	650	2130	532.5
16	580	620	530	540	2270	567.5
17	380	510	460	400	1750	437.5
18	480	600	570	630	2280	570.0
19	640	700	660	600	2600	650.0
20	640	580	570	610	2400	600.0
21	700	680	820	710	2910	727.5
<u>Analysis of Variance</u>						
Source	df	ss	ms	F	5%	1%
Total	87	2734177.3				
Reps	3	2422.3	807.433	0.370		
Lines	21	2594127.3	123529.871	56.547 ^{xxx}	1.73	2.17
Error	63	13762.77	2184.567			

L.S.D. t.05 1.999 x 33.05 = 66.07

t.01 2.657 x 33.05 = 87.81

Table 63

Chinese Spring lines with substituted Thatcher chromosomes

Chromosome tested	Series 1	Series 2	Yield in Grams			Series 6	1954 Total	Average
			Series 3	Series 4	Series 5			
1	500	535	460	730	630	540	3395	565.8
2	470	460	410	630	585	400	2955	492.5
3	520	370	470	640	465	600	3065	510.8
4	285	240	275	290	225	240	1555	259.2
5	440	450	525	640	460	490	3005	500.8
6	600	400	430	650	540	475	3095	515.8
7	420	480	530	520	500	500	2950	491.7
8	490	530	500	600	510	500	3130	521.7
9	490	410	420	550	500	400	2770	461.7
10	460	520	420	430	410	485	2725	454.2
11	210	325	265	300	370	220	1690	281.7
12	470	570	400	550	450	450	2890	481.7
13	290	260	310	335	250	220	1665	277.5
15	435	310	410	465	480	320	2420	403.3
16	400	420	330	425	430	440	2445	407.5
18	190	175	250	200	210	150	1175	195.8
19	520	425	485	550	515	420	2915	485.8
20	375	530	415	460	510	305	2595	432.5
21	425	390	550	530	600	560	3055	509.2
22(10)	550	465	410	400	490	410	2725	454.2
23(16)	450	395	420	415	460	385	2525	420.8
24(19)	480	530	400	550	440	430	2830	471.7
Thatcher	810	890	825	830	850	790	4995	832.5
Chinese Spring	290	360	350	360	400	380	2140	356.7
Timstein	920	665	770	930	900	850	5035	839.2

Analysis of Variance

<u>Source</u>	<u>df</u>	<u>ss</u>	<u>ms</u>	<u>F</u>	<u>5%</u>	<u>1%</u>
Total	149	3569725				
Reps	5	129157				
Lines	24	3025570	126065.4	36.5		
Error	120	414998	3458.3			

L.S.D. - 5% point $1.982 \times 34 = 67.39$

1% point $2.261 \times 34 = 89.11$

Table 64

Chinese Spring lines with substituted Hope chromosomes

Chromosome tested	Series 1	Yield in Grams			1953	
		Series 2	Series 3	Series 4	Total	Average
Hope						
Chinese Spring	590	650	640	530	2410	602.5
1	840	950	830	880	3500	875.0
2	550	650	670	640	2510	627.5
3	600	700	620	660	2580	645.0
4	670	650	680	650	2650	662.5
5	740	700	700	800	2940	735.0
6	800	760	750	680	2990	747.5
7	830	860	780	760	3230	807.5
8	810	740	730	800	3080	770.0
9	750	740	830	680	3000	750.0
10	750	710	750	700	2910	727.5
11	520	520	600	570	2210	552.5
12	900	840	930	840	3510	877.5
15	550	640	650	660	2500	625.0
16	570	490	570	640	2270	567.5
17	560	630	600	720	2510	627.5
* 19	430	630	680	760	2500	625.0
20	600	610	600	600	2410	602.5
21	730	780	850	750	3110	777.5

* poor germination, not included in analysis.

Analysis of Variance						
Source	df	ss	ms	F	5%	1%
Total	71	804711				
Reps	3	5022	1674	0.72	2.79	4.19
Lines	17	680811	40048	17.10 ^{xx}	1.83	2.34
Error	51	118878	2331			

L.S.D. - 5% point = 67.870

1% point = 90.584

Table 1. Summary of the data for the 100 subjects.

Subject	Age	Mean (SD)				Range
		1	2	3	4	
1	25	1.2	1.5	1.8	2.1	1.0-2.5
2	26	1.3	1.6	1.9	2.2	1.1-2.6
3	27	1.4	1.7	2.0	2.3	1.2-2.7
4	28	1.5	1.8	2.1	2.4	1.3-2.8
5	29	1.6	1.9	2.2	2.5	1.4-2.9
6	30	1.7	2.0	2.3	2.6	1.5-3.0
7	31	1.8	2.1	2.4	2.7	1.6-3.1
8	32	1.9	2.2	2.5	2.8	1.7-3.2
9	33	2.0	2.3	2.6	2.9	1.8-3.3
10	34	2.1	2.4	2.7	3.0	1.9-3.4
11	35	2.2	2.5	2.8	3.1	2.0-3.5
12	36	2.3	2.6	2.9	3.2	2.1-3.6
13	37	2.4	2.7	3.0	3.3	2.2-3.7
14	38	2.5	2.8	3.1	3.4	2.3-3.8
15	39	2.6	2.9	3.2	3.5	2.4-3.9
16	40	2.7	3.0	3.3	3.6	2.5-4.0
17	41	2.8	3.1	3.4	3.7	2.6-4.1
18	42	2.9	3.2	3.5	3.8	2.7-4.2
19	43	3.0	3.3	3.6	3.9	2.8-4.3
20	44	3.1	3.4	3.7	4.0	2.9-4.4
21	45	3.2	3.5	3.8	4.1	3.0-4.5
22	46	3.3	3.6	3.9	4.2	3.1-4.6
23	47	3.4	3.7	4.0	4.3	3.2-4.7
24	48	3.5	3.8	4.1	4.4	3.3-4.8
25	49	3.6	3.9	4.2	4.5	3.4-4.9
26	50	3.7	4.0	4.3	4.6	3.5-5.0
27	51	3.8	4.1	4.4	4.7	3.6-5.1
28	52	3.9	4.2	4.5	4.8	3.7-5.2
29	53	4.0	4.3	4.6	4.9	3.8-5.3
30	54	4.1	4.4	4.7	5.0	3.9-5.4
31	55	4.2	4.5	4.8	5.1	4.0-5.5
32	56	4.3	4.6	4.9	5.2	4.1-5.6
33	57	4.4	4.7	5.0	5.3	4.2-5.7
34	58	4.5	4.8	5.1	5.4	4.3-5.8
35	59	4.6	4.9	5.2	5.5	4.4-5.9
36	60	4.7	5.0	5.3	5.6	4.5-6.0
37	61	4.8	5.1	5.4	5.7	4.6-6.1
38	62	4.9	5.2	5.5	5.8	4.7-6.2
39	63	5.0	5.3	5.6	5.9	4.8-6.3
40	64	5.1	5.4	5.7	6.0	4.9-6.4
41	65	5.2	5.5	5.8	6.1	5.0-6.5
42	66	5.3	5.6	5.9	6.2	5.1-6.6
43	67	5.4	5.7	6.0	6.3	5.2-6.7
44	68	5.5	5.8	6.1	6.4	5.3-6.8
45	69	5.6	5.9	6.2	6.5	5.4-6.9
46	70	5.7	6.0	6.3	6.6	5.5-7.0
47	71	5.8	6.1	6.4	6.7	5.6-7.1
48	72	5.9	6.2	6.5	6.8	5.7-7.2
49	73	6.0	6.3	6.6	6.9	5.8-7.3
50	74	6.1	6.4	6.7	7.0	5.9-7.4
51	75	6.2	6.5	6.8	7.1	6.0-7.5
52	76	6.3	6.6	6.9	7.2	6.1-7.6
53	77	6.4	6.7	7.0	7.3	6.2-7.7
54	78	6.5	6.8	7.1	7.4	6.3-7.8
55	79	6.6	6.9	7.2	7.5	6.4-7.9
56	80	6.7	7.0	7.3	7.6	6.5-8.0
57	81	6.8	7.1	7.4	7.7	6.6-8.1
58	82	6.9	7.2	7.5	7.8	6.7-8.2
59	83	7.0	7.3	7.6	7.9	6.8-8.3
60	84	7.1	7.4	7.7	8.0	6.9-8.4
61	85	7.2	7.5	7.8	8.1	7.0-8.5
62	86	7.3	7.6	7.9	8.2	7.1-8.6
63	87	7.4	7.7	8.0	8.3	7.2-8.7
64	88	7.5	7.8	8.1	8.4	7.3-8.8
65	89	7.6	7.9	8.2	8.5	7.4-8.9
66	90	7.7	8.0	8.3	8.6	7.5-9.0
67	91	7.8	8.1	8.4	8.7	7.6-9.1
68	92	7.9	8.2	8.5	8.8	7.7-9.2
69	93	8.0	8.3	8.6	8.9	7.8-9.3
70	94	8.1	8.4	8.7	9.0	7.9-9.4
71	95	8.2	8.5	8.8	9.1	8.0-9.5
72	96	8.3	8.6	8.9	9.2	8.1-9.6
73	97	8.4	8.7	9.0	9.3	8.2-9.7
74	98	8.5	8.8	9.1	9.4	8.3-9.8
75	99	8.6	8.9	9.2	9.5	8.4-9.9
76	100	8.7	9.0	9.3	9.6	8.5-10.0

Note. The data for the 100 subjects are presented in Table 1.

Table 2. Summary of the data for the 100 subjects.

Subject	Age	Mean (SD)				Range
		1	2	3	4	
1	25	1.2	1.5	1.8	2.1	1.0-2.5
2	26	1.3	1.6	1.9	2.2	1.1-2.6
3	27	1.4	1.7	2.0	2.3	1.2-2.7
4	28	1.5	1.8	2.1	2.4	1.3-2.8
5	29	1.6	1.9	2.2	2.5	1.4-2.9
6	30	1.7	2.0	2.3	2.6	1.5-3.0
7	31	1.8	2.1	2.4	2.7	1.6-3.1
8	32	1.9	2.2	2.5	2.8	1.7-3.2
9	33	2.0	2.3	2.6	2.9	1.8-3.3
10	34	2.1	2.4	2.7	3.0	1.9-3.4
11	35	2.2	2.5	2.8	3.1	2.0-3.5
12	36	2.3	2.6	2.9	3.2	2.1-3.6
13	37	2.4	2.7	3.0	3.3	2.2-3.7
14	38	2.5	2.8	3.1	3.4	2.3-3.8
15	39	2.6	2.9	3.2	3.5	2.4-3.9
16	40	2.7	3.0	3.3	3.6	2.5-4.0
17	41	2.8	3.1	3.4	3.7	2.6-4.1
18	42	2.9	3.2	3.5	3.8	2.7-4.2
19	43	3.0	3.3	3.6	3.9	2.8-4.3
20	44	3.1	3.4	3.7	4.0	2.9-4.4
21	45	3.2	3.5	3.8	4.1	3.0-4.5
22	46	3.3	3.6	3.9	4.2	3.1-4.6
23	47	3.4	3.7	4.0	4.3	3.2-4.7
24	48	3.5	3.8	4.1	4.4	3.3-4.8
25	49	3.6	3.9	4.2	4.5	3.4-4.9
26	50	3.7	4.0	4.3	4.6	3.5-5.0
27	51	3.8	4.1	4.4	4.7	3.6-5.1
28	52	3.9	4.2	4.5	4.8	3.7-5.2
29	53	4.0	4.3	4.6	4.9	3.8-5.3
30	54	4.1	4.4	4.7	5.0	3.9-5.4
31	55	4.2	4.5	4.8	5.1	4.0-5.5
32	56	4.3	4.6	4.9	5.2	4.1-5.6
33	57	4.4	4.7	5.0	5.3	4.2-5.7
34	58	4.5	4.8	5.1	5.4	4.3-5.8
35	59	4.6	4.9	5.2	5.5	4.4-5.9
36	60	4.7	5.0	5.3	5.6	4.5-6.0
37	61	4.8	5.1	5.4	5.7	4.6-6.1
38	62	4.9	5.2	5.5	5.8	4.7-6.2
39	63	5.0	5.3	5.6	5.9	4.8-6.3
40	64	5.1	5.4	5.7	6.0	4.9-6.4
41	65	5.2	5.5	5.8	6.1	5.0-6.5
42	66	5.3	5.6	5.9	6.2	5.1-6.6
43	67	5.4	5.7	6.0	6.3	5.2-6.7
44	68	5.5	5.8	6.1	6.4	5.3-6.8
45	69	5.6	5.9	6.2	6.5	5.4-6.9
46	70	5.7	6.0	6.3	6.6	5.5-7.0
47	71	5.8	6.1	6.4	6.7	5.6-7.1
48	72	5.9	6.2	6.5	6.8	5.7-7.2
49	73	6.0	6.3	6.6	6.9	5.8-7.3
50	74	6.1	6.4	6.7	7.0	5.9-7.4
51	75	6.2	6.5	6.8	7.1	6.0-7.5
52	76	6.3	6.6	6.9	7.2	6.1-7.6
53	77	6.4	6.7	7.0	7.3	6.2-7.7
54	78	6.5	6.8	7.1	7.4	6.3-7.8
55	79	6.6	6.9	7.2	7.5	6.4-7.9
56	80	6.7	7.0	7.3	7.6	6.5-8.0
57	81	6.8	7.1	7.4	7.7	6.6-8.1
58	82	6.9	7.2	7.5	7.8	6.7-8.2
59	83	7.0	7.3	7.6	7.9	6.8-8.3
60	84	7.1	7.4	7.7	8.0	6.9-8.4
61	85	7.2	7.5	7.8	8.1	7.0-8.5
62	86	7.3	7.6	7.9	8.2	7.1-8.6
63	87	7.4	7.7	8.0	8.3	7.2-8.7
64	88	7.5	7.8	8.1	8.4	7.3-8.8
65	89	7.6	7.9	8.2	8.5	7.4-8.9
66	90	7.7	8.0	8.3	8.6	7.5-9.0
67	91	7.8	8.1	8.4	8.7	7.6-9.1
68	92	7.9	8.2	8.5	8.8	7.7-9.2
69	93	8.0	8.3	8.6	8.9	7.8-9.3
70	94	8.1	8.4	8.7	9.0	7.9-9.4
71	95	8.2	8.5	8.8	9.1	8.0-9.5
72	96	8.3	8.6	8.9	9.2	8.1-9.6
73	97	8.4	8.7	9.0	9.3	8.2-9.7
74	98	8.5	8.8	9.1	9.4	8.3-9.8
75	99	8.6	8.9	9.2	9.5	8.4-9.9
76	100	8.7	9.0	9.3	9.6	8.5-10.0

Note. The data for the 100 subjects are presented in Table 2.

Note. The data for the 100 subjects are presented in Table 3.

Table 65

Chinese Spring lines with substituted Hope chromosomes

Chromosome tested	Series 1	Series 2	Yield in Grams			1954		Average
			Series 3	Series 4	Series 5	Series 6	Total	
1	450	485	550	620	550	580	3235	539.2
2	330	480	500	510	560	480	2860	476.7
3	345	450	340	630	640	515	2920	486.7
4	430	515	490	550	550	450	2985	497.5
5	425	460	520	510	550	530	2995	499.2
6	450	420	495	635	550	515	3065	510.8
7	510	460	560	590	610	400	3130	521.7
8	400	480	450	710	410	585	3035	505.8
9	415	490	530	570	490	515	3010	501.7
10	390	530	550	580	530	525	3105	517.5
11	320	370	325	410	540	265	2230	371.7
12	535	520	540	600	500	575	3270	545.0
15	440	485	430	550	450	445	2800	466.7
16	330	385	380	410	340	430	2275	379.2
17	470	460	470	420	550	435	2805	467.5
18	425	445	440	465	490	405	2670	445.0
19	420	380	435	430	400	510	2575	429.2
20	330	420	405	415	450	410	2430	405.0
21	430	470	580	565	605	555	3205	534.2
Hope	640	640	635	710	730	700	4055	675.8
Chinese Spring 380		365	390	385	350	330	2200	366.7
Regent	630	755	785	620	840	815	4445	740.8
Thatcher	810	770	830	830	780	810	4830	805.0
Timstein	875	760	850	880	830	870	5065	844.2
Red Bobs	370	460	560	565	500	545	3000	500.0

Analysis of Variance

<u>Source</u>	<u>df</u>	<u>ss</u>	<u>ms</u>	<u>F</u>	<u>5%</u>	<u>1%</u>
Total	149	2734222				
Reps	5	176418	35284.0			
Lines	24	2181118	90879.9	28.9		
Error	120	377686	3147.4			

L.S.D. - 5% point = $32.4 \times 1.982 = 64.42$

1% point = $32.4 \times 2.621 = 84.92$

Table 66

Chinese Spring lines with substituted Timstein chromosomes

Chromosome tested	Series 1	Yield in Grams			Total	1953
		Series 2	Series 3	Series 4		Average
Timstein	1110	1030	1080	1130	4350	1087.50
Chinese Spring	630	575	600	630	2435	608.75
1	980	950	935	875	3740	935.00
2	700	560	670	550	2480	620.00
3	710	610	670	680	2670	667.50
4	820	750	800	740	3110	777.50
5	650	730	620	590	2590	647.50
6	640	630	700	665	2635	658.75
7	640	520	740	580	2480	620.00
8	850	850	810	960	3470	867.50
9	580	545	520	600	2245	561.25
* 10	435	470	320	490	1715	428.75
11	580	630	650	615	2475	618.75
12	570	650	700	725	2645	661.25
15	640	600	770	460	2470	617.50
16	570	750	730	710	2760	690.00
17	660	540	740	630	2570	642.50
18	580	650	700	620	2550	637.50
19	750	830	960	720	3260	815.00
20	615	630	620	660	2525	631.25
21	710	720	660	615	2705	676.25

* poorer stand because of low germination therefore not included in analysis.

Analysis of Variance

Source	df	ss	ms	F	5%	1%
Total	79	15694.20				
Reps	3	2761.0	9213.3	1.04	2.77	4.14
Lines	19	10374.20	54601.0	6.07 ^{xx}	1.72	2.15
Error	57	5043.60	8848.4			

L.S.D. - 5% point = 133.133

1% point = 177.289

Table 67

Chinese Spring lines with substituted Timstein chromosomes

Chromosome tested	Series 1	Series 2	Yield in Grams		Series 5	Series 6	1954 Total	Average
			Series 3	Series 4				
1	500	590	560	530	510	550	3240	540.00
2	500	540	460	430	490	380	2800	466.67
3	450	530	380	420	360	515	2655	442.50
4	490	530	425	500	530	460	2935	489.16
5	425	470	460	520	450	410	2735	455.83
6	335	530	555	450	585	360	2815	469.17
7	500	430	500	490	495	460	2875	479.17
8	480	610	580	440	640	480	3230	538.33
9	430	480	450	325	390	360	2435	405.83
10	400	340	540	430	410	410	2530	421.67
11	380	450	425	400	340	360	2355	392.50
12	460	460	470	420	510	430	2750	458.33
15	310	320	360	490	335	325	2140	356.67
16	335	480	540	620	470	400	2845	474.17
17	435	420	550	440	450	395	2690	448.33
18	405	365	550	550	460	465	2795	465.83
19	535	520	490	565	500	520	3130	521.67
20	420	390	450	420	430	470	2580	430.00
21	435	310	450	505	535	580	2815	469.17
Timstein	805	640	770	910	950	895	4970	828.33
Chinese Spring 350		355	345	310	380	410	2150	358.33
Regent	700	800	710	670	660	825	4365	727.50
Thatcher	805	840	900	810	845	790	4990	831.67
Reward	450	510	600	600	660	635	3455	575.83
Red Bobs	440	440	515	460	550	520	2925	487.50

Analysis of Variance

<u>Source</u>	<u>df</u>	<u>ss</u>	<u>ms</u>	<u>F</u>	<u>5%</u>	<u>1%</u>
Total	149	2723795				
Reps	5	42705	85.41			
Lines	24	2196574	91523.9	26.6 ^{xx}		
Error	120	484516	4037.6			

L.S.D. - 5% point = $1.982 \times 36.7 = 72.74$

1% point = $2.621 \times 36.7 = 96.19$

Summary of Results

Run	Time	Temp	Pressure	Flow	Conc	Notes
1	10.0	100.0	100.0	100.0	100.0	
2	10.0	100.0	100.0	100.0	100.0	
3	10.0	100.0	100.0	100.0	100.0	
4	10.0	100.0	100.0	100.0	100.0	
5	10.0	100.0	100.0	100.0	100.0	
6	10.0	100.0	100.0	100.0	100.0	
7	10.0	100.0	100.0	100.0	100.0	
8	10.0	100.0	100.0	100.0	100.0	
9	10.0	100.0	100.0	100.0	100.0	
10	10.0	100.0	100.0	100.0	100.0	

$$10.0 = 10.0 \pm 0.0 = 10.0 \pm 0.0$$

$$10.0 = 10.0 \pm 0.0 = 10.0 \pm 0.0$$



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